USER INTERFACE DESIGN FOR TOUCH SCREEN BASED NAVIGATION SYSTEMS

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MASTER OF DESIGN

By

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INDIAN INSTITUTE OF TECHNOLOGY KANPUR
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CERTIFICATE

It is certified that the work contained in the thesis entitled "**User Interface Design for Touch Screen Based Navigation Systems**", by **Adesh Kumar Singh** has been carried out under my supervision and that work has not been submitted elsewhere for a degree.

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Dated: July 2004

ABSTRACT

The study of human computer interaction is becoming an important consideration, while designing user interfaces for public information systems. It is also important to study user behavior and their interaction with the system, so that overall interface should reflect an intuitive design approach. Creating user scenarios and usability testing, these systems can be refined to achieve the desired goal.

Nowadays touch screen based public information systems are being used in many places for novice users. Since there is a single mode of input (i.e. finger touch), it is very easy to use them without having prior knowledge of computers. An experiment has been conducted to study user's interaction with a touch screen based gaming application. The empirical data analysis suggests the ways to improve human performance characteristics over touch screen-based systems.

Another part of this thesis is to design an Information Kiosk Interface for providing easy navigation of academic area of IIT Kanpur. A Kiosk is a stand-alone PC mounted on a structure that function as a source of information. It includes human interaction with the system through the means of touch screen. The results from the previous experiment have been implemented in this system to make it efficient and easy to use. The Design of this system involves the study of *Human Computer Interaction* and *User Centered Design Processes*. The process includes, study of existing systems, user interviews, conceptual ideas, developing prototypes, feedback collection, modifications and troubleshooting.

ACKNOWLEDGEMENTS

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To My Family

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Introduction

The term "User Interface" refers to the methods and devices that are used to accommodate interaction between machines and the human beings who use them (users). User interfaces can take on many forms, but always accomplish two fundamental tasks: communicating information from the machine to the user, and communicating information from the user to the machine. The devices that are used to implement user interfaces on modern computers are video screens, keyboards, and pointing devices such as mice, track balls, touch pads and touch screens.

Majority of people in India are not exposed to computer technology and due to this, most of the public information systems have been designed according to the users' familiarity with the systems. Interactive Voice response Systems (IVRS) are successful in most of the application because Most of the people are familiar with the interface of conventional telephony. But main challenge comes in designing information systems where user can participate in interacting with the computer interfaces and can retrieve the desired information. Touch screen technology provides an easy and efficient approach for designing user interfaces for public information systems.

Interaction over the touch screen is the most "Direct" form of interaction in HCI. The zero displacement between input and output, control and feedback makes touch screen very intuitive to use, particularly for novice users. Besides its directness, touch screen also have special limitations. First, the user's finger, hand or arm can obscure the screen. Second, human finger has a very low resolution. All these limitation must be considered while designing interfaces with touch screen as a basic mode of interaction.

The study of user's behaviour is an important task before designing any interface. In case of touch screen interaction, the basic mode of input is finger touch over the screen. Finger has a very low resolution, due to which it is difficult to point at small targets. This problem can be solved either by increasing the target size or by keeping the target size as it is and using some high precision methods to point at that. Few researches have been done in this field, but all those methods are time consuming hence less preferred in most of the applications.

This thesis work explores the study of Human Computer Interaction in touch screen based information systems, design issues of such systems and implementations. An experiment has been conducted for studying the user habits and behaviours while interacting over touch screen. The empirical data analysis suggests the ways to improve human performance characteristics over touch screen-based systems.

The main contributions of this thesis are as follows:

- A new set of rules for keeping the parameters of interaction elements over the touch screens such as buttons size, colour, texture etc.
- Implementation of these results in an Information Kiosk for academic area of IIT Kanpur.

The organization of the thesis is as follows:

Chapter 1:

This chapter describes the various areas of design such as Interaction Design, Fitts' law, Infographics, Cartography and Iconic Communication including the study of Human factors such as mental models in HCI and Mind Maps. In continuation, different techniques to visualize and represent information have been described here. In the end of this chapter an introduction of usability engineering and user centered design processes has been described.

Chapter 2:

This chapter describes the history of touch screen technology, types of touch screens, and its implementations in interaction design. This chapter also deals with the study of

User Interface Design issues for touch screen based Public Information Kiosks. A brief analysis of High Precision Touch Screen Interaction is described in the last section of this chapter.

Chapter 3:

This chapter covers an experiment conducted to study user's behaviour towards a touch screen based navigation gaming application. The experimentation goals, procedure, and final analysis of data have been described here. The visualization of the discrete data collected from the users has been included for better understanding of the scenario.

Chapter 4:

This chapter consists of the complete design process involved in developing the interface for touch screen based information kiosk for IIT Kanpur. It involves, problem definition, need statement, specification and constrains, concept development, design process, prototyping and usability issues

Chapter 4:

This concluding chapter summarizes the contributions of the thesis and point out the directions of possible further work in this field.

1.1 Preliminaries

This chapter covers a brief study of various areas of design, which contributes to the science of human-machine interaction. The main focus is on the interaction of human and computer through the medium of visual communication techniques. This chapter will discuss briefly about various aspects of Interaction Design, Iconic Communication, Human Cognitive Processes, Mantel Models, Information Visualization, Cartography, Navigational Systems and Usability Engineering. All these aspects collectively contribute to the complete design process.

1.2 Interaction Design

"He is not paying attention to me. I don't like his responses whenever I talk to him, and his way of talking is unbearable. He is unable to communicate with me. I am not going to talk to him any more".

These kinds of problems we face mostly with people around us. Sometimes we don't like their way to communicate and sometime we don't like their behavior. In this kind of human-human communication, people normally try to avoid such awkward situations. But when it comes to human- machine interaction, there are many limitations which have to be considered and users has to compromise on the interaction with the machines. With the evolution of technology and information systems, it became very essential to create an interactive environment for the users, so that efficiency of machines as well as users can be increased. With the evolution of Graphical User Interface (GUI) and multimedia, the interface elements became efficient enough to communicate with the user. Nowadays, almost every successful multimedia system has a strong communication and interactive feature in it. Like other design aspects, interaction design too has some rules and principles, which should be known a priori for a usable design.

1.2.1 Basic Principles of Interaction Design

Effective interfaces always follow basic principles to develop interaction between user and the application. With the evolution of technologies, so much of works has been done to improve the human- machine interaction, but most of these principles always remain constant.

Effective interfaces always assume that a user is unaware of inner working of the system, hence provides a flexible environment. User can undo his unwanted activities at anytime as system gives the option to log user's activities. These interfaces give user, a sense of control over the system. User can easily and quickly see all the command and controls and can achieve the desired goal efficiently. In continuation, system should be efficient enough to perform maximum task, with the minimum input from the user.

Some of the basic principles of interaction design are as follows:

(i) Anticipation

Users expectations should be satisfied by the application. To evoke necessary action user should not search for the information and system should bring all the tools and information needed for every step of process.

(ii) Autonomy

User should be given a task environment to work upon, which provides him a comfortable level of autonomy over the system. Users feel most comfortable in an environment that is neither confining nor infinite, an environment explorable, but not hazardous.

Status mechanism is a must when system takes longer time to perform a series of tasks and help workers to respond appropriately to changing conditions.

(iii) Color Blindness

Eight percent of the men suffer a cellular alteration of the retina that prevents them to perceive the colors properly. A color-blind person does not distinguish the difference between some colors. The interface should be designed considering these conditions as normal person can have a small degree of color blindness.

(iv) User Efficiency

All user-centered designs reflect the consideration of user efficiency, not the machines. For example, consider four icons of 4x4 pixel named *Icon1, Icon2, Icon3* and *Icon4* on a 1024x764 screen resolution. Keep *Icon1 and Icon2* in the top-left and top-right corner of the screen respectively. Keep *Icon3 and Icon4* in the middle of screen and the gap between two icons is 800 pixels. Now ask user to start clicking *Icon1 and Icon2,* one after another for few seconds. Repeat the same process with *Icon1 and Icon2.* Which of the two cases has faster clicking with minimum error?

Generally speaking, with *Icon3 and Icon4* should be faster then Case 2 with *Icon1 and Icon,2* since the distance between the icons is more in Case 2, but if we consider users efficiency, this is not the correct answer.

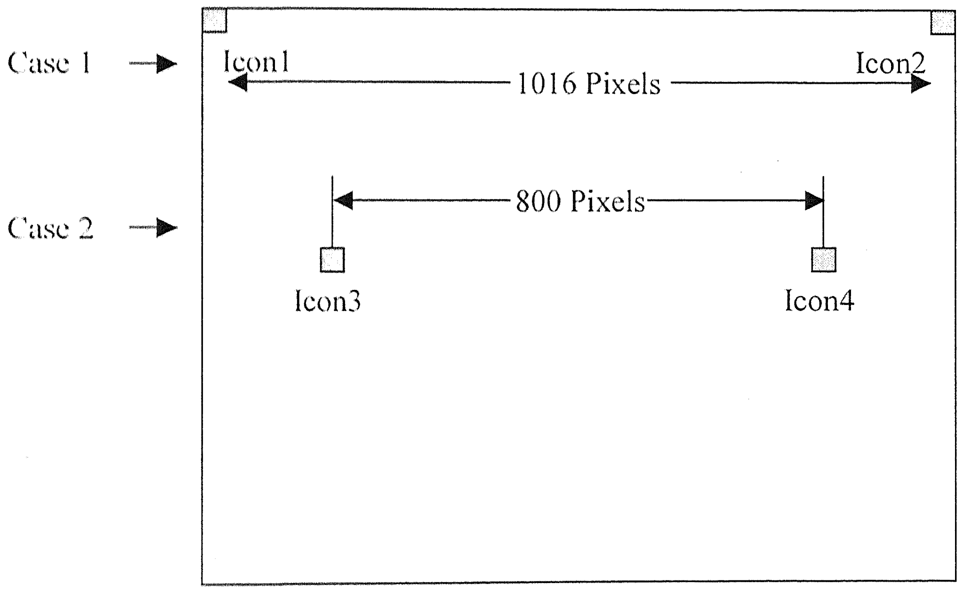


Figure 1.2.1: Screen Layout with 1024 x 768 resolution

All the four corners of screen provide the most accurate access to the mouse pointer and users can access these four points very easily even if they close their eyes. Whereas in Case 2, even if the distance between the two icons is less, the user has spend a fraction of a second to stop his mouse exactly over the icon. This process then slows down the access speed of the icons.

To improve the efficiency of the whole working system, it is very much necessary to improve the efficiency of user along with the rest of the elements of the system.

(v) Consistency ("Principle of least astonishment")

This implies that an interface should present a harmony or agreement between all areas and within those areas to present a solid or consistent whole. In a good design, consistency must relate to behaviors of object directly. Objects or visual element should be visually consistent, which act in a similar way. Inconsistency must be maintained between the objects of different behavior.

(vi) Defaults

Defaults always help users to navigate faster as most of the options can be skipped because of their default selection. Defaults should be decided based on users expectations and they should be responsive.

(vii) Explorable Interfaces

Interface should provide user, a well-defined path to achieve a desired goal. User should be able to get job done in the quickest way possible. Stable visual elements gives user a sense of home also helps in fast navigation. If users perform something unusual or undesired, then they should be able to go back to the previous state. By making actions reversible, users can explore as well as navigate through unknown option without having a fear of getting trapped.

(ix) Human Interface Objects

In an interactive environment, interface objects play a vital role in interacting with the user. These objects have life and they are the key elements throughout the interface, which actually communicates with the user. Most of them have standard way of interaction and resulting behavior. These objects should be self-consistent, stable and understandable.

(x) Latency Reduction

Users have the tendency to loose interest if a system gives slow responses on users actions. To hold the attention of user, it is very much necessary to reduce the latency. All the buttons or links should be acknowledged by a feedback within 50 milliseconds. If a

process is taking more then 2 seconds to respond, it is better to show a status icon. Progress indicators can be used to acknowledge longer tasks. Multiple clicks should be trapped if user is working on a low bandwidth system, so as to prevent the system to become slower.

(xi) Two Second Rule:

This Principle states that a user should not need to wait more than two seconds for certain types of system responses, such as launch of a application or application switching.

(xii) Learnability

For first timers some learning environment must be given for every application, irrespective of how easy is the product. Users generally interact with the product and achieve instant mastery.

(xiii) Metaphors

Metaphors are the very important elements, which actually deals with the human perception and thought process. To grasp the finest details of the conceptual model, metaphors are very helpful as they evoke the people's perception such as sight, sound, touch etc.

For example, Windows 98 has an object called *Recycle Bin.* Its propose in real life is to collect unused item and recycle then whenever necessary. In windows 98 it's functioning is similar as it collects all the deleted files and data and that data can be revert back whenever needed.

(xiv) Protect User's Work

The greatest fear, which users are having, is loss of data as a result of their error. User should be ensured that the data couldn't be lost easily. This can be done using automatic data backup techniques and providing options to go back to the previous state.

(xv) Readability

Clear visibility of visual elements is a must in an interface. Better visibility of text, images and other elements helps in reducing time to recognize them and to navigate fast. Text that must be read should have high contrast over a contrasting background, such as

black over white, yellow over black, white over black, etc. Font size should be large enough for comfortable reading so as to reduce strain in the eyes.

(xvi) Human Memory Limitations

Human memory has many limitations, which has to consider while designing effective interfaces. Information should be organized in small chunks of data, which should match user expectations. Let users recognize rather than recall information.

(xvii) Modality

Using modes is another important task in any interface design. A mode is an interface state where what the user does has different actions than in other states (e.g. changing the shape of the cursor can indicate whether the user is in an editing mode or a browsing mode).

1.2.2 Fitts's Law

Interface design is always based on the interpretations. A design, which can work for one person, may not work for other. Designers can rely on one rule for interface design, known as *Fitts's Law*. This law can be applied to software interfaces as well as web site designs as it involves the way people interact with mouse and other pointing devices. There are certain characteristics of visual elements on the screen that make them easy and hard to click on. The farther is mouse pointer from the target, the more effort it will take to reach on. Also if target is smaller, it's difficult to click upon. This shows that, it is easy to target bigger icons near to the mouse pointer.

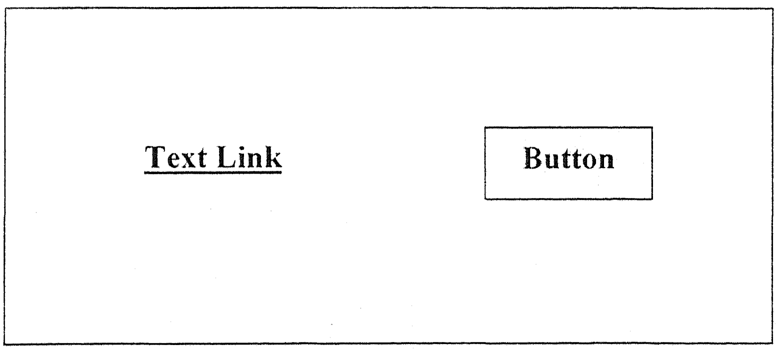


Figure 1.2.2: A Text link and a rectangular button

For example, we can see from figure 1.2.2 that a text link can be clicked only over the text area and there is no additional area around to click upon, whereas a rectangular button gives a sufficient area to access it by mouse pointer

It seems intuitive that the distance moved would affect movement time and the precision demanded by the size of the target to which one is moving. Fitts discovered that movement time was a logarithmic function of distance when target size was held constant, and that movement time was also a logarithmic function of target size when distance was held constant. Mathematically, Fitts' law is stated as follows:

$MT = a + b \log2 (2A/W)$

Where

- MT = movement time
- a, b = regression coefficients
- A = distance of movement from start to target center
- W = width of the target

1.3 Mental Models in Human Computer Interaction

"In interacting with the environment, with others, and with the artifacts of technology, people form internal, mental models of themselves and of the things with which they are interacting. These models provide predictive and explanatory power for understanding the interaction."

-Norman (in Gentner & Stevens, 1983)

1.3.1 Overview

Mental models are cognitive structures that have an important impact on everything we do. Whenever human being interact with their environment, they develop internal representations of it. Such representation in head are known as Mental Models. These models have been studied by cognitive scientists as part of efforts to understand how humans know, perceive, make decisions, and construct behavior in a variety of environments. The relatively new field of Human-Computer Interaction (HCI) has

adopted and adapted these concepts to further the study in its main area of concern (usability). A person may have several different models for different environment.

Kenneth Craik formulated the theory of mental models in the early 40's. He sought to provide a general explanation of the human thought based on the assertion that humans represent the world they interact with through mental models. Johnson Laird (1983) based his theory on Craik's assumption stating that an individual holds a working model of a certain phenomenon in order to understand it. Mental models are not necessarily a visual representation of the real life case, neither they are more complex representations.

1.3.2 Types of Mental Models

In the early 1980's, two basic mental models were identified, which are *Structural* and *functional* models. Structural models, which are also known as *Surrogate Model*, define facts the user has about how a certain system works. On the other hand, functional models, also called *Task-Action Mapping Models*, are procedural knowledge about how to use the system. The main advantage of functional models is that they can be constructed from existing knowledge about a similar domain or system. *Structural models are context free while functional models are context sensitive.*

1.3.3 Development of Mental Models

When a person interacts with its surrounding environment, he receives sequences of stimuli that can be used either to activate a person's existing mental models or initiate the development of new ones. If a model does not exist then learning processes provide the mechanisms by which new models can be generated. Second, if a model exists, but it leads to incorrect behavior then, through feedback and failures, models can be modified. We can see from figure 3.1.1, how learning process causes development of new mental models and modification of existing ones.

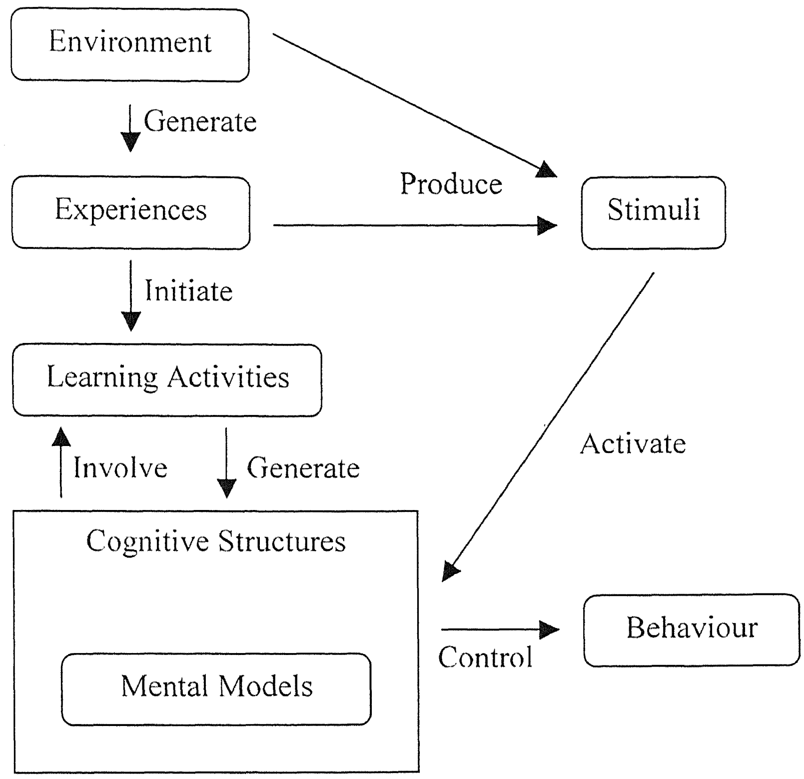


Figure 1.3.1: Overview of the learning process

As can be seen from figure 1, mental models are developed as a consequence of learning activities; these may be both conscious and sub-conscious.

1.3.4 Mental Models in HCI

Most of the researchers have suggested four basic models in Human Computer Interface (HCI) that affect the way users interact with a system.

- *User's model of the system*, which is the model, constructed at the users' side through their interaction with the target system.
- *System's model of the user*, which is the model, constructed inside the system as it runs through different sources of information.
- *Conceptual model* which is an accurate and consistent representation of the target system held by the designer or an expert user.

- *Designer's model of the user's model*, which is basically constructed before the system exists by looking at similar systems or prototype or by cognitive models or task analysis.

Figure 1.3.2 shows relation between all the above four mental models.

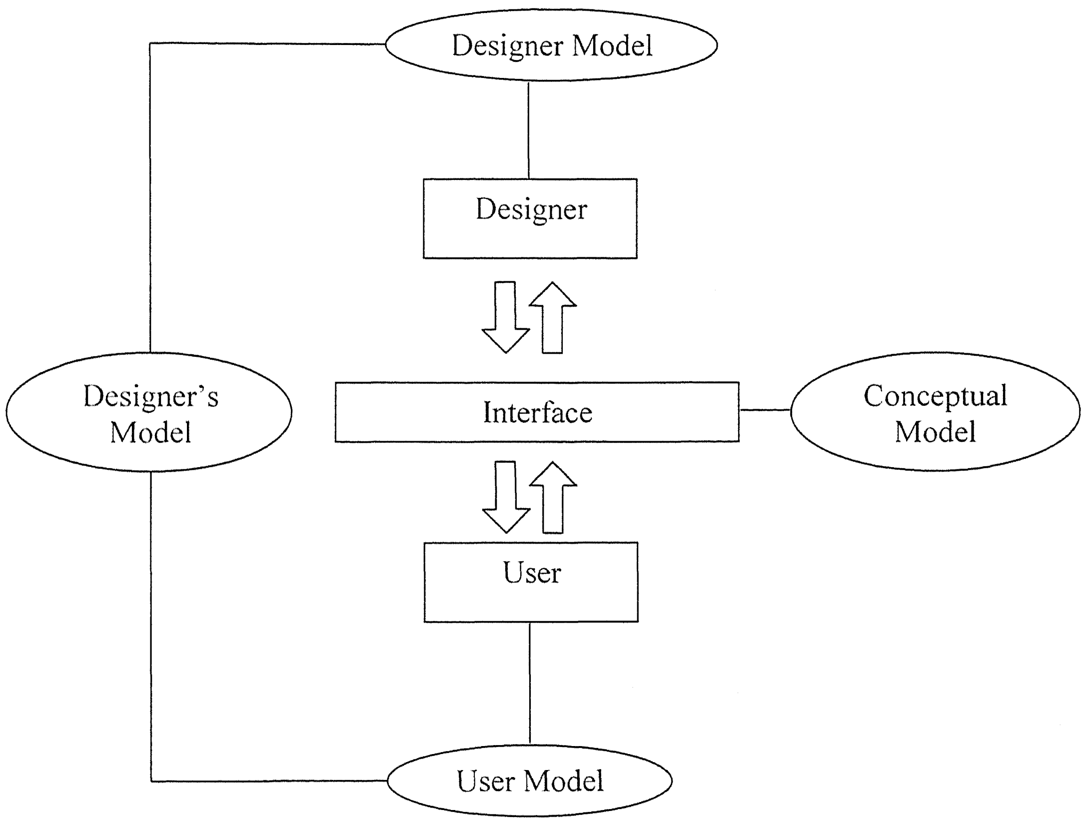


Figure 1.3.2: Mental Models in HCI

1.3.5 Design Considerations

Software interfaces should be designed to help users build productive mental models of a system. Common design methods include the following factors:

- ***Simplicity:*** Since mental models simplify reality, interface design should simplify actual computer functions. A function should only be included if a task analysis

shows it is needed. Basic, most frequently used functions should be immediately apparent, while advanced functions should be less obvious to users.

- ***Familiarity:*** As mental models are built upon prior knowledge, it's important to use this fact in designing a system. Relying on the familiarity of a user with an old, frequently used system gains user trust and help accomplishing a large number of tasks.

- ***Flexibility:*** An interface should allow users to choose the method of interaction that is most appropriate to their situation. Users should be able to use any object in any sequence at any time.

- ***Affordance:*** Affordances provide clues to how an object can be used and manipulated. An interface can take advantage of affordances by using real-world representations of objects in the interface. Users will intuitively know what to do with the object just by looking.

- ***Availability:*** Since recognition is always better than recall, an efficient interface should always provide cues and visual elements to relieve the user from the memory load necessary to recall the functionality of the system.

- ***Feedback:*** A system should provide complete and continuous feedback about the results of actions. Immediate feedback allows users to assess whether the results were what they expected.

1.4 Mind Maps

A British Psychologist, Tony Buzan, originated the mind map concept in late 60's. Mind map is a picture that represents semantic connection between portions of learned materials. Mind map is a natural function of human mind. It is a powerful graphical technique to explore the potential of the brain. It gives you the freedom to roam the infinite expanses of your brain. The mind remembers key words and images, not sentences. Because mind maps are more visual and depict associations between key words, they are much easier to recall than linear notes. The Mind Map can be applied to every aspect of life where improved learning and clearer thinking will enhance human performance.

Tony Buzan suggests Mind Map Laws and "How To Mind Map?" in a step-to-step procedure. Here is brief description of Mind Map Laws.

1.4.1 Mind Map Laws

- These are the brain-reflecting foundation structures of a Mind Map. The more of them you follow, the more effective your Mind Map.
- Start in the center with an image of the topic, using at least 3 colours.
- Use images, symbols, codes and dimensions throughout your Mind Map.
- Select key words and print using upper or lower case letters.
- Each word word/image must be alone and sitting on its own line.
- The lines must be connected, starting from the central image. The central lines are thicker, organic and flowing, becoming thinner as they radiate out from the center.
- Make the lines the same length as the word/image.
- Use colours – your own code – throughout the Mind Map.
- Develop your own personal style of Mind Mapping.
- Use emphasis and show associations in your Mind Map.
- Keep the Mind Map clear by using Radiant hierarchy, numerical order or outlines to embrace your branches.

1.4.2 How To Mind Map

- Turn a large A4 (11.7" x 8.3") or preferably A3 (16.7" x 11.7"), white sheet of paper on its side (landscape), or use a Mind Map pad.
- Gather a selection of colored pens, ranging from fine nib to medium and highlighters.
- Select the topic, problem or subject to be Mind Mapped.
- Gather any materials or research or additional information.
- Start in the center with an unframed image – approximately 6cm high and wide for an A4 and 10cm for an A3.
- Use dimension, expression and at least three colours in the central image in order to attract attention and aid memory.
- Make the branches closest to the center thicker, attached to the image and 'wavy' (organic). Place the Basic Ordering Ideas (BOIs) or the 'chapter heading' equivalents on the branches.
- Branch thinner lines off the end of the appropriate BOIs to hold supporting data (most important closest).
- Use images wherever possible.
- The image or word should always sit on a line of the same length.
- Use colours as your own special code to show people, topics, themes or dates and to make the Mind Map more beautiful.
- Capture all ideas (your own or others'), then edit, re-organize, make more beautiful, elaborate or clarify as a second stage of thinking.

1.4.3 How to read a Mind Map

- Start in the center - that is the FOCUS of the Mind Map
- Words/Images closest to the central image show the MAIN THEMES of the Mind Map. This is the start of the radiant hierarchical structure
- Select one main theme and read out from the center along the branch. This provides greater levels of associated detail. Proceed around the Mind Map, either in the order of your choice or as suggested by the author
- Notice links between the branches

Consider an example of "Elements of Creativity". If we have to create a Mind Map for this topic, we should move according to the given figure 1.4.1. Starting with the major topics like purpose, brain, climate, techniques and process, it proceeds further into sub-topics of these topics. Finally we have a complete graph of "Elements of Creativity" with different nodes and link. Using these techniques, we can easily review all the parts and their relationships with other entities.

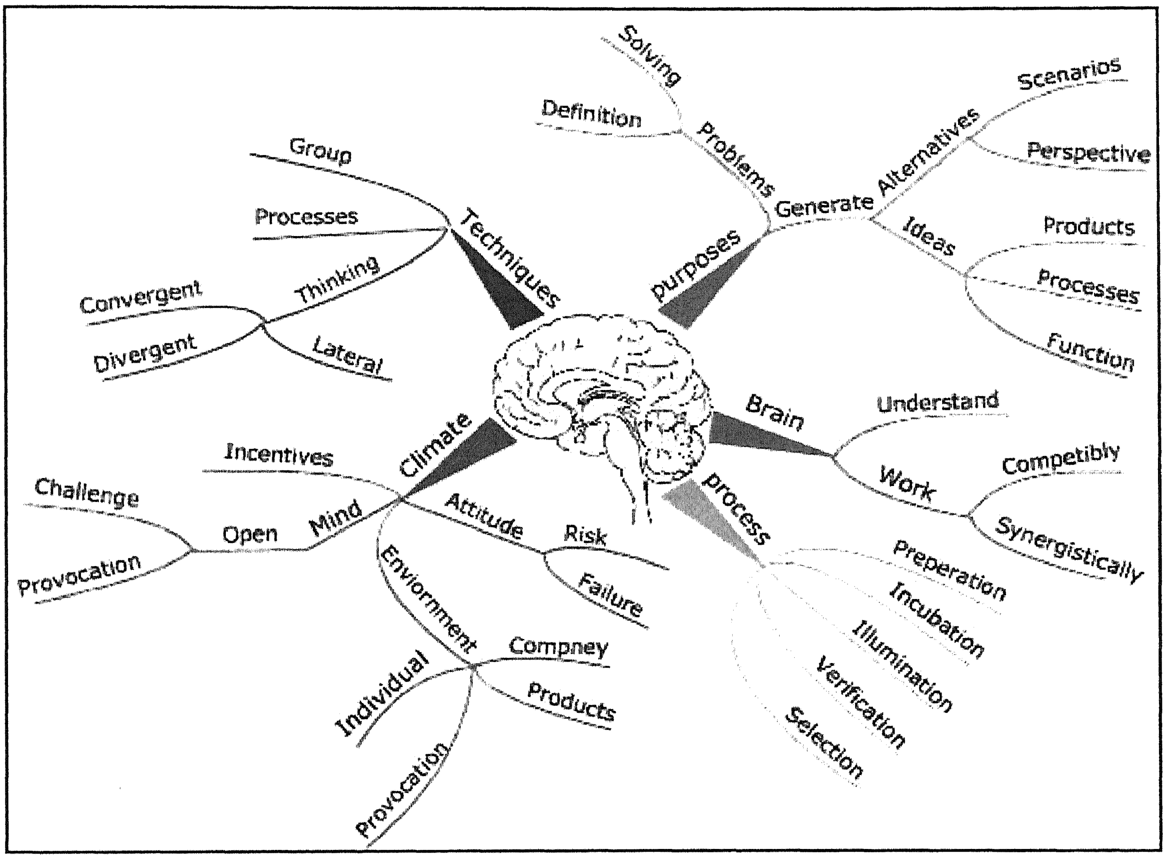


Figure 1.4.1 A Mind Map for "Element of Creativity"

What was the need to study Mind Maps? The answer is simple; this technique can be applied to almost every field where we need a structured approach to solve problem or to achieve a goal. This technique can be easily applied in the filed of information design, web design, and related fields.

1.5 Iconic Communication

Icons and symbols are major part of communication since from the evolution of human civilization and they are still used widely in almost every part of the world. The main cause of their extensive usage is their expressiveness and independent nature. Comparing icons & symbols with the existing languages world over, they have a major advantage of being accepted everywhere and amongst all human being of different ethnicity.

1.5.1 History of Pictorial Communication

History of pictorial communication is very old and people have been interested in pictures for a long time. According to art historians, early art was often iconographic, depicting symbols, as these Egyptian symbols for fractions illustrate, rather than aspiring to three-dimensional realism. Because of the potentially arbitrary relation between a symbol and what it denotes, a symbol itself is not a picture. Symbols, nevertheless, have from the very beginning found their way into many pictures, and we now must live with both the symbolic and geometric aspects of pictorial communication.

In the 1950s, Charles Bliss developed a set of atomic icons that represent basic objects in the world and their features (Bliss, 1965). These can be combined to form complex icons that map on to the set of words found in natural languages (Figure 1.5.1) including such linguistic entities as pronouns. Blissymbolics has been used as the basis of several computer based systems of communication.

Mouth – Ear—Language-- Electricity --Telephone

Figure 1.5.1: The construction of the Bliss symbol for *"Telephone"*

1.5.2 Iconic Communication in HCI

Our motive here is to discuss the role of icons and symbols in Human Computer Interface. With the introduction of WIMP interfaces (Windows-Icons-Menus-Pointer), possibilities for developing new forms of human communication based around images rather than text has emerged. Focussing on terminology, the first question comes mind is "what icons are and why they are special?" The naive answer is that an icon refers to an object by simply representing it. Thus by recognising the image in Figure 1.5.2 as a man we know that it refers to a man. This is quite different from the word "man" whose relationship to the object it refers to is seen as arbitrary, conventional and simply has to be learned.

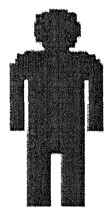


Figure 1.5.2: Icon for 'man'

Some people may recognize it as a man and some as a 'class' of men. The meaning of the icon may not simply be its denotation but rather its pragmatic effect.

Given that some signs are intended to rely to a greater degree on their iconicity then how are we to judge their success? Again, the most common assumption is that they are successful if we can recognise their referent when we first see them. If a large proportion of people recognise what a particular icon stands for, then it is a successful icon. The road sign for a bridge does not try to represent the view that we normally have of a bridge, but more to the way that bridges are represented on maps (Figure 1.5.3). We first have to recognise this reference and then transfer it to our immediate environment.

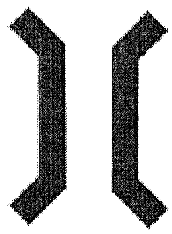


Figure 1.5.2: Icon for 'Bridge'

The significant task of recognition is usually assumed to occur when the icon is first encountered, but there is a strong case to be made that it is more important that the meaning of the icon is remembered. Icons are also rarely used in isolation. Whether we consider icons as road traffic signs, for directions in zoos, or as tools within a computer program, the most common applications of icons is within sets. Here the criteria for success will not involve recognition alone but will also include differentiation from other icons in the set.

The use of metaphors within icon systems has its own problems. Creating icons for every function can prove problematic. Many applications have a large number of functions and if every one has to be represented by a different icon this can be difficult. There are problems both in creating so many different images within what is traditionally a very limited medium (a 32 x 32 bit square), and also in displaying so many icons on the screen at the same time. One solution to these latter problems is that of grouping the icons into subsets, each of which is represented by another icon. Clicking on this 'group' icon will cause the subset to be displayed.

Most of the researchers suggest that, use of icons should be seen in terms of syntax, semantics and pragmatics, which suggest a strong connection with linguistics. Any communication system must allow for change if it is to survive and be continually useful within its domain. It must be designed to change or it will become irrelevant.

1.6 Infographics

September 11, 2001, the day when whole world was thrilled by the two terrestrial attacks on the World Trade Center. The whole world was eagerly waiting for the hot news and it was the high time for all the news agencies to provide the breaking news. Readers all over the world would surely wanted to see more, then text and pictures alone could provide. Visual journalists and graphic artists at every newspaper and TV-station got ready to do their business. It was hard to find good pictures from an actual attack as everything happened unexpectedly. In one of the leading newspaper, a 2-Dimensional figure of plane hitting the building was shown and that was the first thing, which could explain the whole scene and sequences very effectively. Figure 1.7.1 shows the Path of Flight 11 and simultaneous sequences in a graphical form.

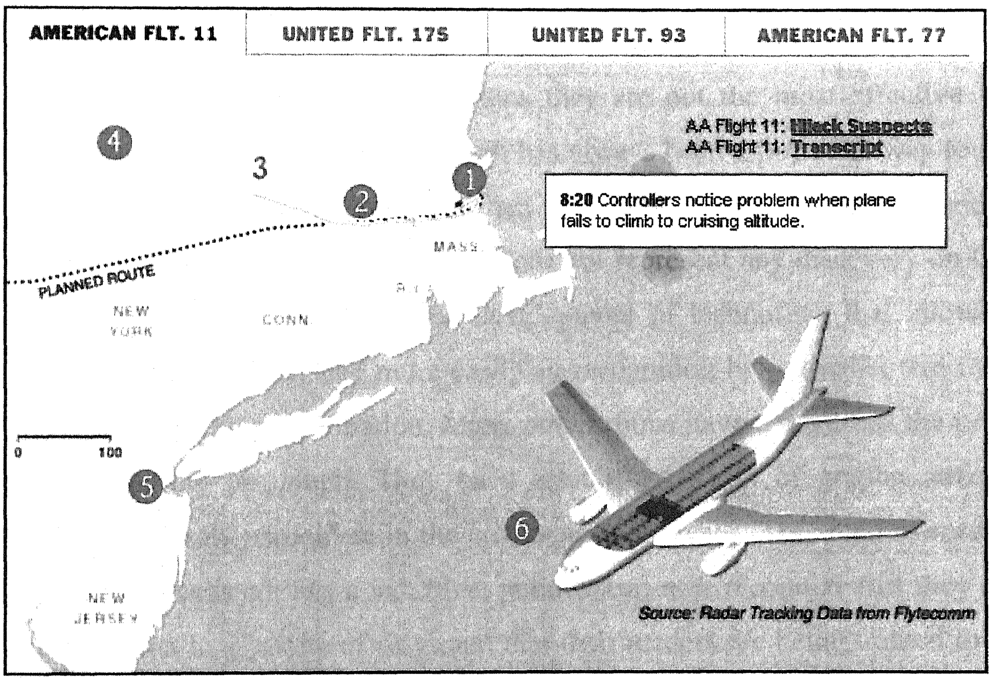


Figure 1.6.1 Infographics of Flight 11, which attacked WTC

1.6.1 Introduction

Textual languages has always been the best tools to describe an idea, a story or a description, but the major disadvantages in textual descriptions are, (a) they are less appealing as compared to visual descriptions, (b) non uniform protocol for people from different regions of the world with different language background. Many major

newspapers used to describe highlighting events in a detailed textual description, but it was very inconvenient way to portray the events and information in the minds of users.

To solve this problem many editors started using pictorial representations to tell a story or to explain any idea. Visual representations were found to be much more effective and impressive, as human mind accepts graphical representations very easily. Then started a new concept of *Informative graphics* or *Infographics.* Informative graphics is now days used in print media such as newspapers, magazines books etc. World Wide Web is the major source of information and infographics has become an essential part of it. Since with the advancements in the technology and faster communication systems infographics has become more interactive and powerful with the effective use animation.

1.6.2 Infographics in Journalism

While words are still the common means of communication for the journalist, they are in no way the only means, and on occasions they are not the most effective tools a journalist can use. The picture, chart or graph has always been a powerful way to convey information to a reader or viewer. The fact that newspapers, magazines and other publications are using then more these days does not represent any discovery on the part of journalist. What it does reflect is the development of technology that allows these forms to be created and published more easily ad recognition by journalist that there are many means of presenting information. Many publications have recognized the necessity of going beyond the paragraph. They have established staffs of graphic artists and journalists who actively participate in the coverage of the news. The trend towards more emphasis on graphics is not just a fad. Most publications now recognize that they need to present information in a variety of ways and that their readers are being trained to expect more visual presentations.

1.6.3 Infographics in Digital Media

World Wide Web is now a days becoming a major source of information and it is no more isolated from informative graphics. With the availability of many tools to design static as well as animated graphics, information can be represented much more effectively. Animated visuals are always found to catch attention of the user. Using animation it is very easy to describe even complex information in a small view area.

WWW supports the interactive environments so that user can see what he wants. Paul Nixon, a web designer's page has links to good infographics. It has shown the examples of interactive online maps, Infographics for War in Iraq and many more with effective use of animation in many of the presentations. Animations and special effects are used now days to illustrate the information in an effective ways. For Example, for demonstrating a bank robbery using infographics, there can be many ways. First, a two-dimensional graphical presentation showing all the sequences on a time line, or using time stamps. Another way is to create a storyboard for all the sequences and showing them one by one with the help of animations. This way is more efficient for information representation and can be implemented easily in a digital media.

1.6.4 Infographics in Business Communication

Business presentations are no longer untouched by this art. There are number of infographics, but the most common ones are maps, chart, type-based and illustration based. Using a chart, crucial piece of data are depicted visually so that the reader can the point of data at a glance. A chart can show trends over time and the relationships between different pieces of information. Maps are generally used to show geographical information. A type-based infographics provides condensed small bits of information in a geographically designed space. Illustration based infographics are diagrams or cross sections of objects which exists in 3D space.

There are some basic rules, which should be considered while making infographics.

- Simple is always better
- Do not use too many colors or fonts
- Choose appropriate type of infographics for the information
- Always use headings, labels for better description

Infographics can help in communication the ways that we have not thought of.

- Business Plans
- Reports
- Articles
- Trial Presentations
- Product Manuals

1.6.5 Cartography

Journalism is not the only field where infographics is used to present information. Now a days almost every field where there is a need to present any information, visual presentations are preferred. One of the oldest applications is *Cartography*. Cartography is the scientific name for mapmaking. It is one of the most versatile of human creations. It is useful for activities ranging from the sciences to the arts, from the speculative to the practical and from the real to the unreal. Maps are a way of organizing geographic or spatial data for use in human activities. The map serves as an intermediary between a person and the environment by helping people to manage or navigate the environment. Maps have a wide variety of uses and aid us in many ways. When we think of maps, we often think of them as navigation tools. They also have other uses as in helping us to interpret data like land elevations, weather patterns, crop production, etc.

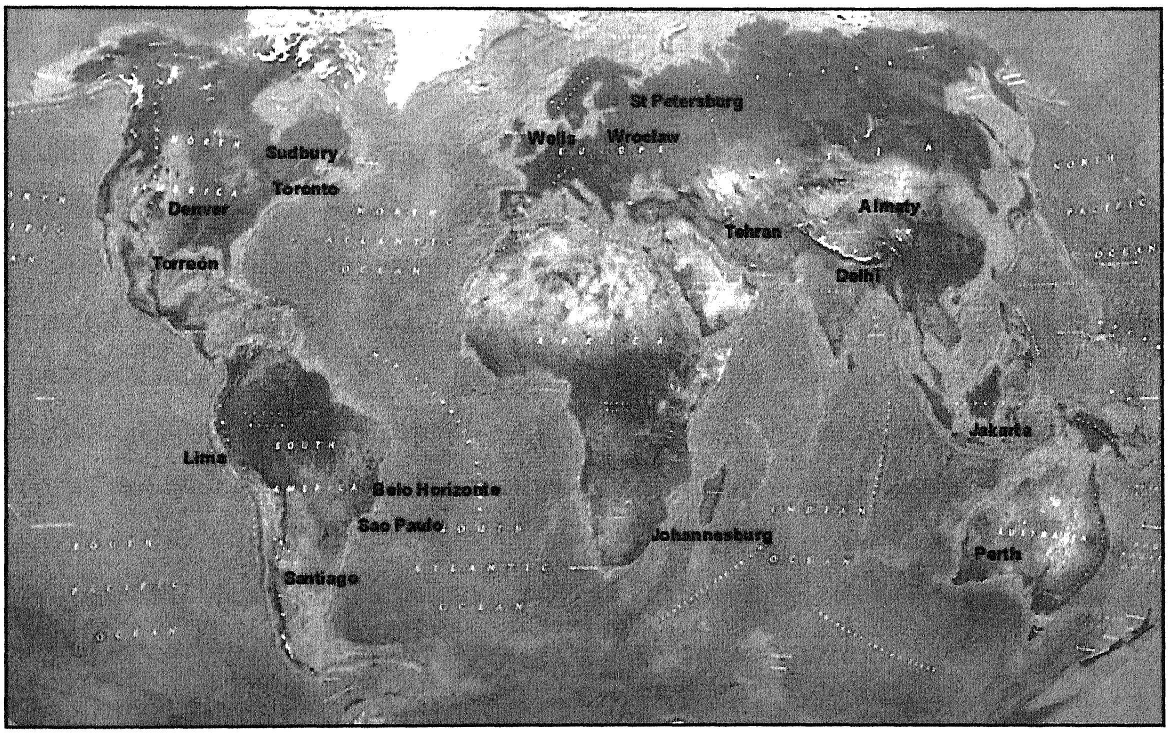


Figure 1.6.2 The World Map, an example of Cartography

1.6.6 Two-Dimensional v/s Three Dimensional

Most of the graphics found in print media is two-dimensional as it can be easily made in a short span of time and the output in the low cost print media is much better. But the main problem comes when we need a different view of the same graphic element. In that

case it becomes essential to reconstruct that element. Now, here comes the 3D-concept and presents itself as a better solution. We still need a person to obtain the reference-material and possibly even allocate more time than before to draw a 3D-model of the object. But now we can use this model in countless positions and thus avoid being visually boring by repeating. We can even zoom in and out on the model, - if the model is detailed enough it's almost like having the object physically located in your computer for you to use again and again, but never in the exact same way. When it comes to software, we have the options from Illustrator, Freehand, Photoshop, and Flash etc. In 3D we can go to Cinema4D, 3DS Max, Maya, Light wave, Rhino, Poser, Bryce, Amapi, Swift, Carrara etc.

1.7 Information Visualization

Information representation is becoming a challenging task when it comes to handle large and complex data or information. *Information visualization*, the computer assisted use of visual processing helps in better understanding of information by the means of graphical representations and simulations. Information visualization is the design and creation of interactive graphic depictions of information by combining principles in the disciplines of graphic design, cognitive science, and interactive computer graphics. As the volume and complexity of the data increases, users require more powerful visualization tools that allow them to more effectively explore large abstract datasets. This thesis involves the study of such visualization tools and to device new techniques to implement into modern information systems such as *Pubic Information Kiosk*.

1.7.1 Background

The History of information visualization is very old, around 38,000 years BC, long before any written language appeared. 8,000 years ago the Sumerians already used tables to keep count of their economic transactions. 2800 years after that they used a pictographic language with almost 2000 signs. At the same time the Egyptians developed their hieroglyphic writing, which would last for another 3,000 years without essential changes.

From pre-historical times up to the middle ages we can find many examples of the developments and innovations related to the visual representation of knowledge. Initially the one requirement of people was to represent different places and locality in an easily understandable format, so the idea of maps evolved and hence a new science called *cartography*, came into the picture. Cartography is the art, science and technology of making maps, together with their study as scientific documents and work of art.

1.7.2 Information Visualization Tools

Information Visualization is the use of computer-supported interactive visual representations of abstract data to amplify cognition. Whereas scientific visualization usually starts with a natural physical representation, Information Visualization applies visual processing to abstract information. It is the computer-assisted use of visual processing to gain understanding, has become a topic of significant development and research. Graphical or visual presentations and simulations are considered as the best tools for understanding and learning a complex problem. *Graphics is the visual means of resolving logical problems.* The key objective is to represent the information or data through the means of visuals, so we need to understand the data and its various forms.

(i) Data

Information visualization starts with information in the form of data. There are many forms that this data could take, from spreadsheets to the text of novels, but much of it can be represented as cases by variable arrays or can be transformed into this form. Text, for example, can be used to compute document vectors, normalized vectors in a space with dimensionality as large as the number of words. The different data types are important in their own right; text has its own characteristic operations, in fact the subcategories of patent text or financial report text have their own unique characteristics and potential unique operations on them.

(ii) Visualizations

An elementary visual presentation consists of a set of *Marks* (which could be Points, Lines, Areas, Surfaces, or Volumes), a *Position* in space and time (the **X**, **Y** plane in classical graphics, but **X**, **Y**, **Z**, **T** 3D space plus time in information visualization), and a

set of "*Retinal*" properties, such as Color and Size). Thus, visualizations are composed from the following visual vocabulary:

Marks:	Point, Line, Area, Surface, and Volume
Automaticity	Processed Graphical Properties
Position:	X, Y, Z, and T
Retinal encoding:	Color, Size, Shape

1.7.3 Types of graphical methods

There are different types of graphical methods, which are generally used for visualizing information. It can be in 1-dimension, 2-dimension, 3-dimension or multiple dimensions. Also they can be temporal, hierarchical or network.

The Graphic Method Should Depend on the Data. The following table 1.7.1 shows the type of method applied to a particular kind of data.

▪ 1- Dimensional - Program source code - Wrapped lines ▪ 2- Dimensional - Geographic data, floor plans - Maps	▪ Temporal - Animation (transitory) - Users need control for: • Speed • Step-by-step • Start and end points - Time lines
▪ 3- Dimensional - Volume data in real world - Needs slicing, transparency, and multiple views	▪ Hierarchical - Budget - Trees
▪ Multi – Dimensional - Most databases - Dynamic queries in 2D or 3Drepresentations	▪ Networks - Communication networks - Node-link diagrams

Table 1.7.1: Types of graphical methods

Some of the examples are as follows:

1. One – dimensional

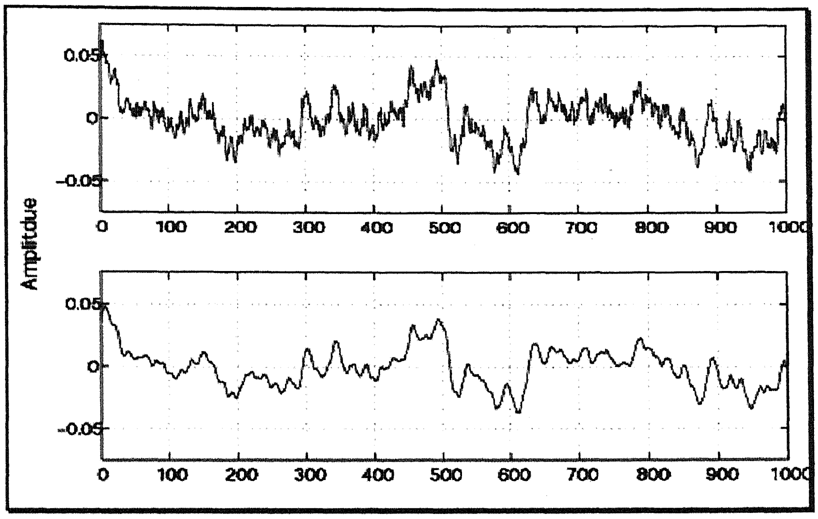


Figure 1.7.1 One Dimensional Visualization

2. Two - dimensional

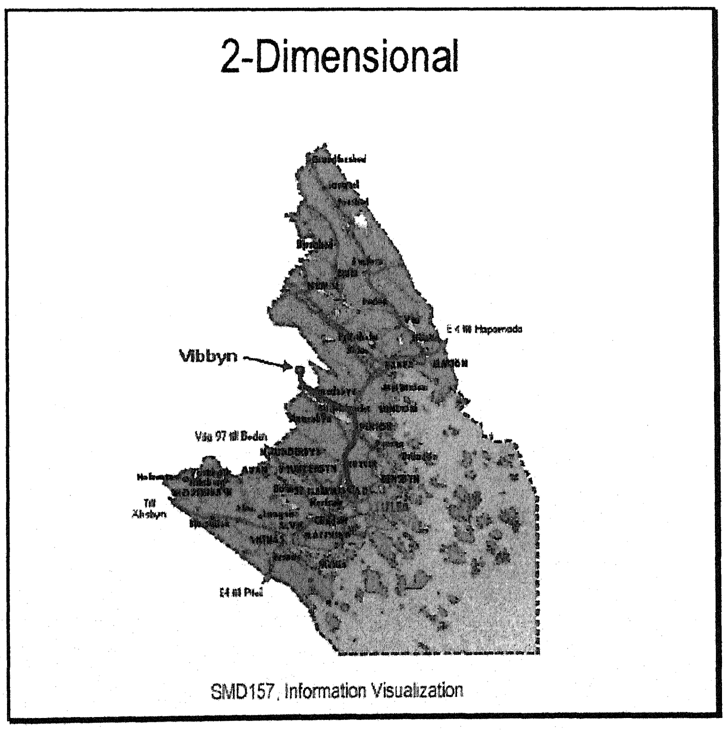


Figure 1.7.2 Two Dimensional Visualization

3. Three Dimensional

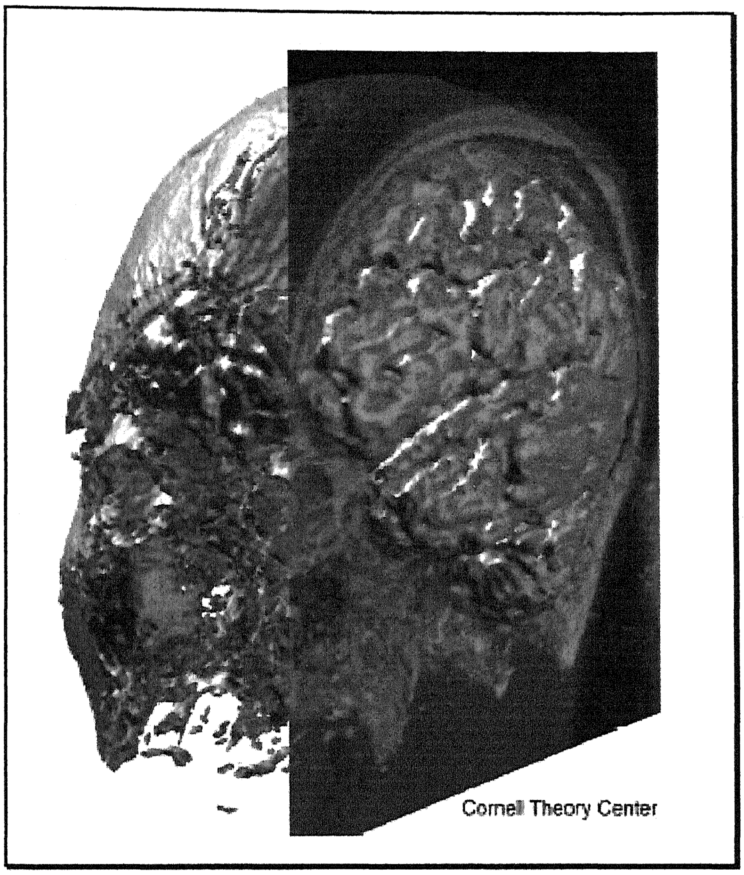


Figure 1.7.3 Three Dimensional Visualization

4. Multi-dimensional visualizations

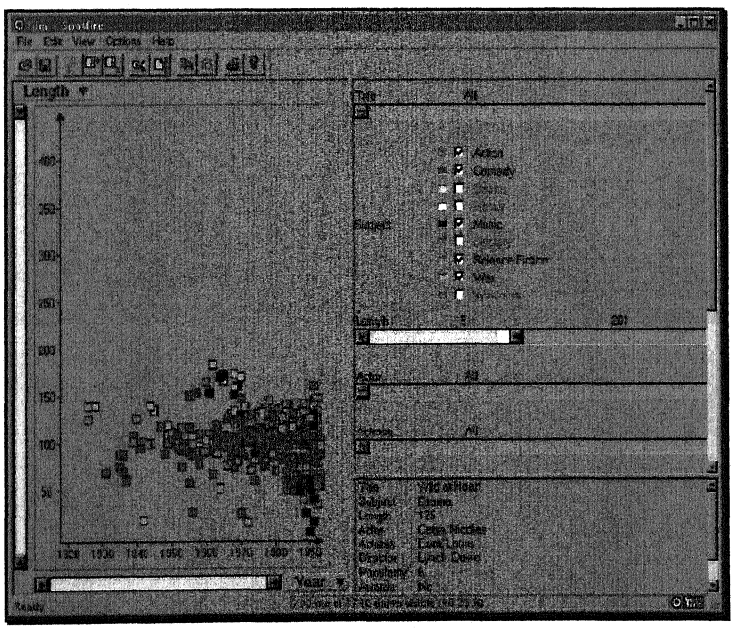


Figure 1.7.4 Multi Dimensional Visualization

5. Networks

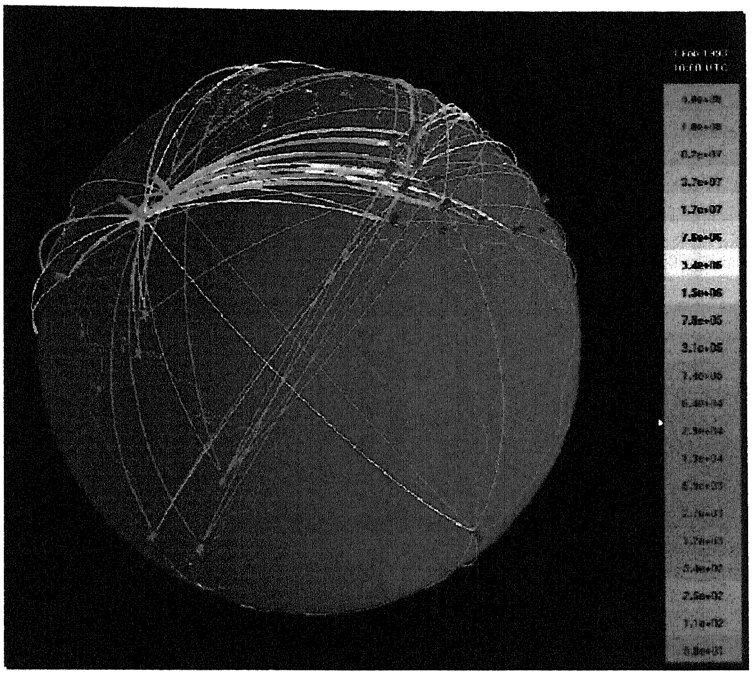


Figure 1.7.5 Network Visualization

6. Hierarchical

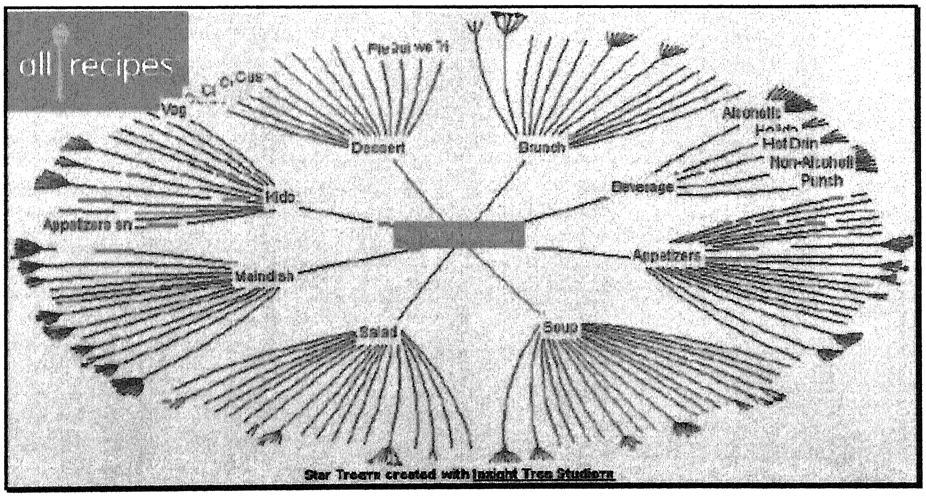


Figure 1.7.6 Hierarchical Visualization

7. Temporal

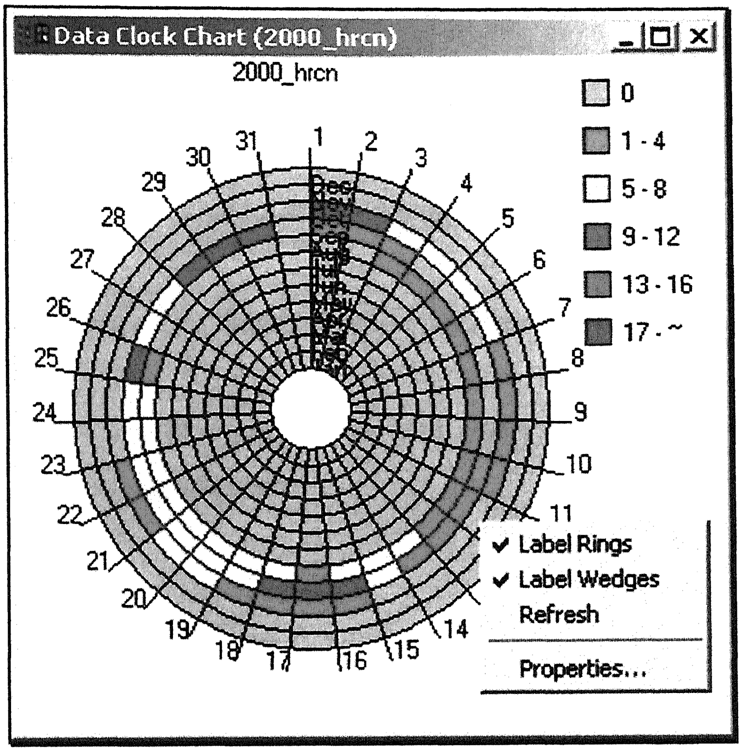


Figure 1.7.6 Temporal Visualization

1.8 Usability Engineering

The words 'usability' and 'usability engineering' have been in use for some time now. Usability evaluation methods are used in industry to measure the usability of products so usability is not a concept that is found associated with computers alone.

The International Organization for Standardization (ISO) defines usability as:

...the effectiveness, sufficient and satisfaction with which specified users can achieve specified goals in particular environments...

ISO DIS 9241-11

The term usability came into existence in early 90's in order to replace the term "user friendly". However, in the past few years, the word usability itself has become almost as devalued as the term it was intended to supplant. There are still many different approaches to making a product usable, and no accepted definition of the term usability. The definitions, which have been used, derive from a number of views of what usability is. Three of the views relate to how usability should be measured:

- The product-oriented view, that usability can be measured in terms of the ergonomic attributes of the product;
- The user-oriented view, that usability can be measured in terms of the mental effort and attitude of the user;
- The user performance view, that usability can be measured by examining how the user interacts with the product, with particular emphasis on either
  - *Ease-of-use:* how easy the product is to use, or
  - *Acceptability:* whether the product will be used in the real world.

1.8.1 Life cycle of usability engineering

Usability engineering is a process. It ensures that usable software is produced and that user requirements are met. The system is guaranteed to be what the user wants and needs. Table 1.8.1 describes usability-engineering life cycle.

Task	*Information Produced*
Know the user	User characteristics
	User background
Know the task	User's current task
	Task Analysis
User requirement capture	User requirements
Setting usability goals	Usability specification
Design Process	Design
Apply guidelines, heuristics	Feedback from design
Prototyping	Prototype for user testing
Evaluation with the users	Feedback for redesign
Redesign and evaluate with the users	Finished product
Evaluate with users and report	Feedback on product for future systems

Table 1.8.1: The usability engineering life cycle model

1.8.2 Understanding of user

Before designing a system or product for users, it is very important to understand the users. If a system is not been able to meet users expectation, then it's a failure, no matter how much intense research has been put into the designing phase. To meet users requirement and to achieve the level of satisfaction, it is very important to study users behavior and psychology. User can be classified in different classes. User can be direct, indirect, support or support. On the basis of expertise level, user can be novice,

intermittent or expert. Information can be gathered from the users using following methods:

- Informal and formal discussions
- Observation
- Putting an expert on the design team
- Questionnaire
- Interview

The following Table 1.8.2 shows user characteristics, which needs to be considered in user study:

User information: ▪ Age range ▪ Educational background ▪ Skills ▪ User classification *Use of the system* ▪ Discretionary or mandatory user *Job details:* ▪ End-user class ▪ Brief job description ▪ Main skills ▪ Responsibilities ▪ Control of work load

Table 1.8.2: User characteristics

1.8.3 Task analysis

To achieve a desired goal user has to go through a series pf processes and task execution. The next important thing after user analysis is *Task Analysis*. In 1988 Norman introduced an *Action Cycle Model*. The action cycle is formed of seven stages: one stage for goals, then three for execution and three for evaluation (Figure 1.8.1).

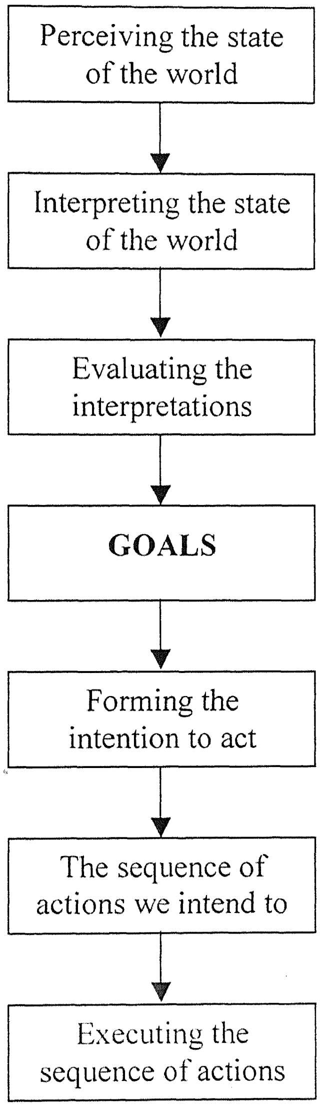


Figure 1.8.1: Normal Action Cycle

Norman suggests that a large number of the difficulties that people experience when they perform everyday tasks are due to poor relationship between the intention of the actor and the physical actions that can be performed on the object they are working with, and the state of that object.

A task consists of an input and output and a process that transforms input to the output. The process of task analysis should produce a clear understanding of what it is that the system must do. There is no method, at present, for ensuring a better solution using task analysis; that requires inspiration!

1.8.4 Usability Attributes

The definition for usability given by ISO gave a starting point in the study of usability of a system, but there were no attributes, which could be measured. ISO doesn't suggest how efficient, how effective or how satisfying the system must be. So there came a need to modify the attribute definitions so that they can be measured and interpreted. If a system achieves measurement, then we can say that the product is usable.

(i) Effectiveness

The effectiveness of a system can defined as:

- The success to failure ratio in completing the task.
- The frequency of use of carious commands of particular language features/functions.
- The measurement of user problems.
- The quality of the output.

(ii) Efficiency

An efficient system, ought to require as little effort as possible:

- The time required performing selected tasks.
- The number of actions required in order performing a task.
- The time spent looking for information in documentation.
- The time spent using on-line help.
- The time spent dealing with error.

(iii) User satisfaction

It seems unlikely that it would be possible to measure the satisfaction of the user while using the system. However, a useful measurement of a user satisfaction can be made if the evaluation team's measurement is based on observation of user's attitude towards the system.

(iv) Learnability

A system should be easy for the user to learn so that it is possible to use it effectively as quickly as possible. How easy a system is to learn can be measured in terms of a novice user's experience of learning how to operate it. A system that is easy to learn will cause the user to be able to carry out a large amount of tasks in a short space of time, thus reflecting how the user quickly learns to operate some areas of the system.

1.8.5 Conclusion

Usability lies in the interaction of the user with the product or system and can only be accurately measured by assessing user performance, satisfaction and acceptability. Any change in the characteristics of the product or system, user, task or environment may produce a change in usability. A product is not itself usable or unusable, but has attributes, which will determine the usability for a particular user, task and environment. These attributes include not only the specifically ergonomic characteristics but also all the characteristics of the product, which impinge on usage including those aspects of software quality (such as efficiency and reliability), which affect ease of use. For a software product, usability is the user's view of software quality.

Chapter 2

Interaction over touch screen systems

2.1 Introduction

With the introduction of touch technology in computer screen, a new field is coming up, which deals with the interaction design issues over the non-conventional modes of interaction with the computer systems such as mouse, keyboard, joystick etc. The implementation of touch screens has solved many problems for novice users and first time users in regards of their interaction with the computer technology without creating any fear of complex input from keyboard or mouse usage. Users can touch whatever he can see on the computer screen. This is like interacting with the real life environment.

This section will describe about the touch screen technology and its implementation in various public systems. A brief case study and some advanced research in this field has also been discussed in this section.

2.2 Touch Screen Technology

Dr. Sam Hurst, founder of Elographics, developed the first "*Touch Sensor*" while he was an instructor at the University of Kentucky in 1971. This sensor was called the "Elograph", and was patented by The University of Kentucky Research Foundation. The "Elograph" was not transparent as are touchscreens, but was a significant milestone for touch technology.

The first true touchscreen came on the scene in 1974, again developed by Dr.Hurst, of Elographics. In 1977, Elographics developed and patented five-wire resistive technology, the most popular touchscreen technology in use today. On February 24, 1994, the company officially changed its name from Elographics to Elo TouchSystems.

When it comes to touchscreen technology, the five most prevalent types are Capacitive, Infrared, Resistive, Surface acoustic wave (SAW) and Guided Wave with Resistive and Capacitive being the most widely used types for industrial applications. All of these technologies have their own distinct characteristics, both advantageous and with limitations. Touch technologies differ in the way a touch is detected. With scanning infrared systems, a touch is registered when a finger or stylus encounters an array of infrared beams. When a user's finger touches a surface-acoustic-wave touch screen, the screen absorbs the acoustic waves propagating on the touch surface. The controller electronics identify a touch by the drop in acoustic signal from the touch location. Capacitive technologies use the conductivity of a finger to shunt a small alternating current to ground through the operator's body. Resistive touch technologies are based on two layers of conductive material held apart by small, nearly invisible spacers. When the screen is touched, the two layers come in contact, and two-dimensional coordinate information is generated by the voltages produced at the touch location. Resistive touch screens are most frequently used in medical equipment, but they also can be found in handheld computers, personal digital assistants, industrial equipment, point-of-sale equipment, office automation equipment, and consumer electronics.

2.2.1 Capacitive Touchscreens

Capacitive touch screen technology is recommended for use in KIOSK applications that require a "finger touch". It will not operate with either a gloved hand or with a mechanical stylus. It is made of glass, which makes it extremely durable and scratch resistant. This glass overlay has a coating that stores the charge deposited over its surface electrically. Capacitive touchscreens operate using oscillator circuits that are located in each corner of the glass overlay and measure the capacitance of the area be "touched". Depending on where the person touches the overlay, the oscillators will vary in frequency. Then a touchscreen controller measures the frequency variations to ascertain

the coordinates of the person's touch. When used with flat panel displays, capacitive offers drift-free stable performance that is not susceptible to deterioration over time. A capacitive touchscreen is impervious to grease, dirt and water, which makes it ideal for frequent use.

2.2.2 Infra-red Touchscreens

Infrared touch screen technology is based on "legacy" technology and is becoming increasingly replaced by Resistive or Capacitive touch systems. Over the years, Infra-red bezels have proven to be a very reliable technology for use in ATMs, Food Service and Preparation, KIOSK, Medical Instrumentation, Process Control Systems, and Transportation Tracking applications. It does not incorporate any sort of "overlay" that could inhibit screen clarity or brightness, but instead, uses a special bezel of LEDs (light emitting diodes) along with diametrically opposing phototransistor detectors which surround the glass of the of the display surface. The controller circuitry scans the screen with an invisible lattice of infrared light beams just in front of the surface that directs a sequence of pulses to the LED's. It then detects information at the location where the LEDs have become interrupted by a stylus or finger. The infrared frame housing the transmitters can impose design constraints on operator interface products. A few limitations are (1) that they usually require low-resolution output of the monitor, (2) can produce activation without touching the screen and (3) the cost to produce the special Infrared bezel is quite high.

2.2.3 SAW (Surface Acoustic Wave)

SAW touch screen technology is suggested for use in ATMs, Amusement Parks, Banking and Financial Applications, Gaming Environments, Industrial Control Rooms, and KIOSK. SAW touch cannot be used within NEMA environments, as the technology cannot be gasket sealed. It has excellent durability that allows it to continue working if scratched since the overlay for the touch sensor is a solid glass display. The disadvantage to this glass overlay is that is breakable and won't work in wash down conditions. The waves are spread across the screen by bouncing off reflector arrays along the edges of the overlay. Two "receivers" then detect the waves. The acoustic wave weakens when the user touches the glass with their finger, gloved hand or soft stylus. The coordinates are then determined by the controller circuitry that measures the time at which the amplitude

declines. It is the only technology that can produce a Z-coordinate axis response. SAW technology offers drift-free stable performance that is always precise. SAW offers superior image clarity, resolution, and high light transmission.

2.2.4 Resistive Touchscreens

Resistive touch screen technology is recommended for use in POS (Point of Sale): Grocery Stores, Hotels, Restaurants and Retail Stores; Industrial Applications: MMI (Man Machine Interface), Machine and Process Control; Portable Devices; Personal Information Management Systems; Transportation Solutions; Medical Solutions: Equipment, Instrumentation and Patient Monitoring Systems. It generally uses a display overlay composed of layers, each with a conductive coating on the interior surface. Special separator "dots" are distributed evenly across the active area and separate the conductive interior layers. The pressure from using either a mechanical stylus or finger produces an internal electrical contact at the "action point" which supplies the controller with vertical and horizontal analog voltages for data input. To reduce parallax for older "curved" CRT applications only, resistive touchscreens are generally spherical to match the curvature of the CRT (true flat resistive touch overlays are also available for TFT flat panels and/or CRTs). Our resistive touchscreens are anti-glare to reduce reflective shine intensity, which will slightly diffuse the light output throughout the screen. Resistive technology offers tremendous versatility in that activation can be initiated by; a gloved hand, fingernail, mechanical stylus or an ungloved finger.

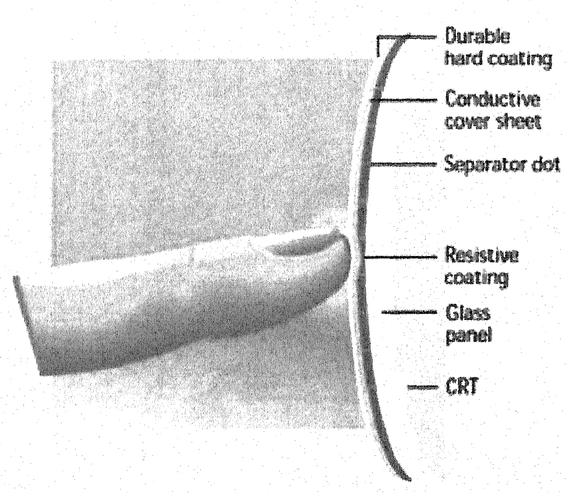


Figure 2.2.1: Components of a five-wire resistive touch screen.

Although resistive touch systems are available in 4, 5, and 8-wire variants, five-wire resistive touch screens offer a good combination of features for use in medical applications because of their construction. Five-wire resistive technology involves a glass substrate overlaid with a suspended polyester cover sheet. Because of its simplicity, five-wire resistive technology is extremely easy to integrate and, therefore, is less expensive than alternative touch options.

Five-wire resistive touch screens have a glass panel with a uniform, resistive metallic coating. A thick polyester cover sheet is tightly suspended over the glass. Small, transparent insulating dots are used to prevent the two surfaces from contacting each other until the screen is touched lightly with a finger or stylus. The cover sheet has a hard, durable coating on the outward-facing side to reduce damage from sharp styli and a conductive metallic coating on the inward-facing side (see Figure 5). A touch on the screen pushes the conductive coating on the cover sheet against the coating on the glass, making electrical contact.

To determine the coordinates of the touch location, a voltage gradient is first applied along the x-axis and then along the y-axis. When a finger or stylus presses the two layers together, the x-axis and y-axis voltages at the point of contact are measured. The voltages produced by the electrical contact are the analog representations of the position touched. The control electronics then transmit the coordinates of the position to the host computer.

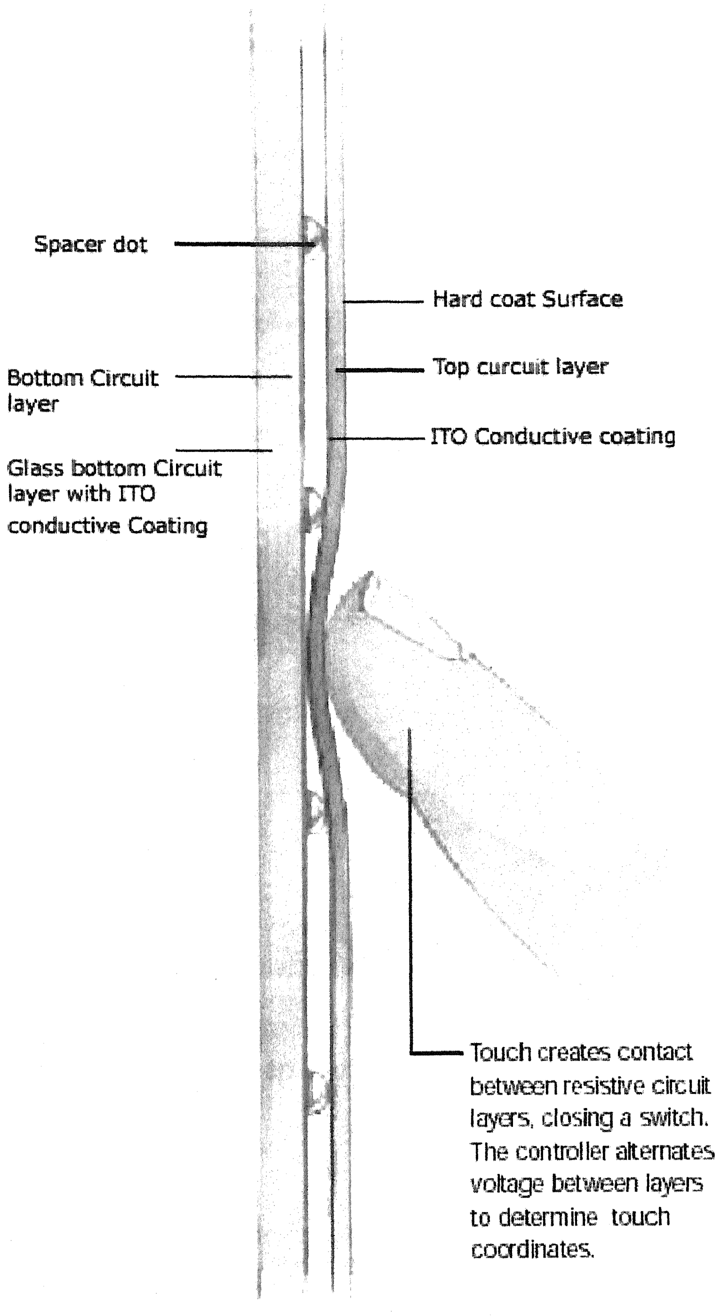


Figure 2.2.2 A five-wire resistive touch screen concept

2.3 Implementation of touch screens

There are many fields where touch screens are widely used. Because of their easy usage, they are preferred for public information systems considering many users who has never seen or used computer ever in their life or less frequent users. Some of the implementations of touch screens are as follows:

1. **Automated Teller Machines**

   Most of the automated teller machines have touch screen interfaces. The interface in such systems is limited to few options, hence user can easily withdraw money; generate queries about his account etc.

Figure 2.3.1 Touch screen interface of an ATM Machine

2. **Public Information kiosks**

   The widely used application of touch screens is public information kiosks. These kiosks generally provide information in the form of interactive presentation supported by audio feedbacks. Users can easily select their choices and desired information just by touching the given links. Some of the kiosks allow users to enter their personal information. For that purpose the following techniques are used generally:

Figure 2.3.2 Public Information Kiosk

- *Virtual Keyboard* is an application, which consists of an array of buttons on the screen arranged in similar fashion as of real keyboard. User can touch the keys on the screen and can get the functionality of a real keyboard.

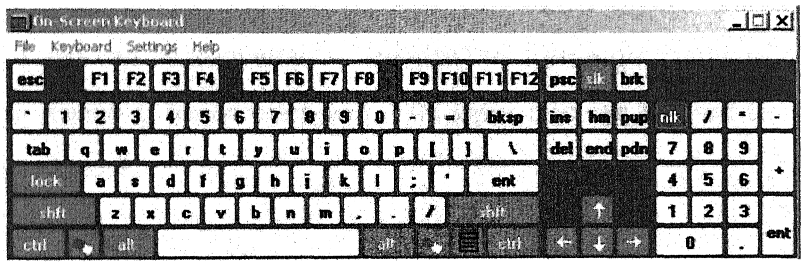


Figure 2.3.3 A virtual keyboard in Microsoft Windows 2000

- Option selection-using check boxes or toggle buttons.

3. **Personal Digital Organizer (PDA)**

PDA is a handheld computing device, which can be carried easily in a pocket. Because of its compactness, the mode of input is through touch screen. Since the resolution is very low, finger touch cannot be used for high precision. For that purpose a stylus pen is used instead of finger.

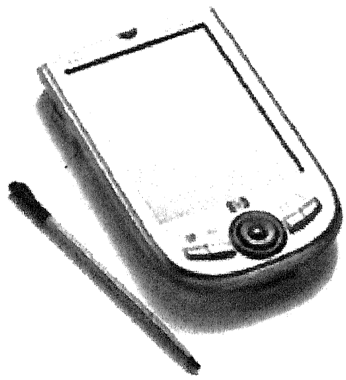


Figure 2.3.4 A PDA with a stylus

4. Tablet PC

Tablet PC is a type of notebook computer that has an LCD screen on which the user can write using a special-purpose pen called *Stylus*. The handwriting is digitized and can be converted to standard text through handwriting recognition, or it can remain as handwritten text. The stylus also can be used to type on a pen-based key layout.

Figure 2.3.5 Tablet PC from Apple

5. Gaming / Entertainment

Touchscreens are used in many gaming/entertainment systems including video lottery terminals (VLTs), lottery ticket dispensing machines. Touch-based VLTs are found in social venues, restaurants, and casinos. Multiple games can be

available on a single machine giving users the option to play poker, blackjack, keno, and other games, without changing machines.

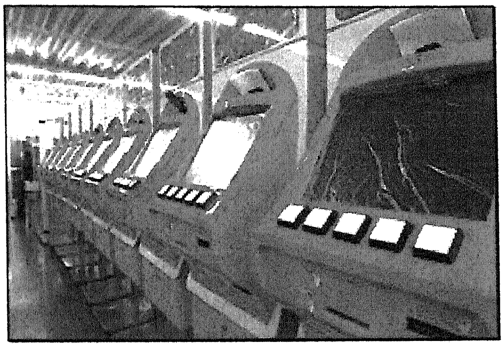


Figure 2.3.6 Touch screen based gaming equipments

6. **Point-of-Sale (POS) Terminals**

Touchscreens are the preferred input device for operators at checkout counters, restaurants, quick-serve chains, and retailers. Many major restaurant companies are using touch-based POS terminals because they offer many advantages over traditional cash registers.

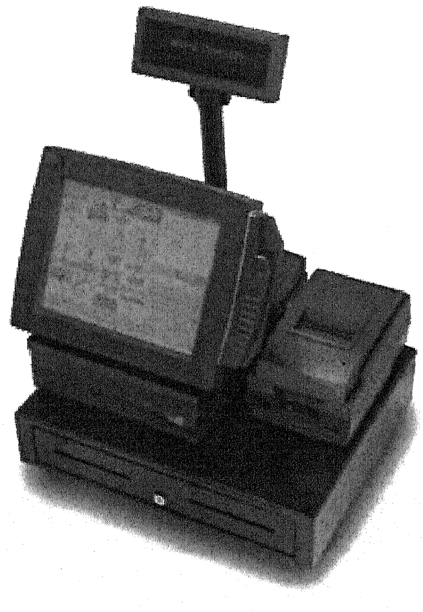


Figure 2.3.7 A point-of-sale terminal

7. **Industrial and Medical Instrumentation**

The practical application of touchscreens with medical equipment is wide and varied. Touchscreens act as an interface for improving the efficiency and accuracy of analytical instruments, sophisticated x-ray and ultrasound machines, and cardiac management machines.

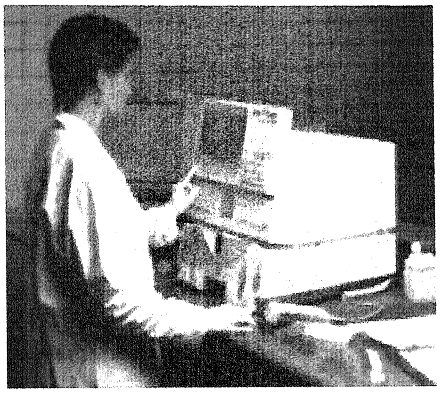


Figure 2.3.8 Touch screen interface of a medical instrument

8. **Automotive accessories**

Automobiles nowadays are coming up with latest technology of navigational systems such as *Global Positioning Systems* (GPS). Touch screens are widely used in such applications for allowing the driver to navigate through various road maps and different controls over the screen.

Figure 2.3.9 Touch screen interface of a GPS equipment in a car

2.4 User interface design issues for touch screen based public information kiosks

There is a continuing trend to develop terminals to deliver information and services to the general public, accessible in public locations. These terminals, or kiosks, can deliver services at the point of need, and at low cost. If the kiosks are networked, information can be transmitted electronically to many sites rapidly to update the database or provide on-line user access.

2.4.1 User requirement definition for the kiosk

An important first step is to define the purpose of the kiosk, the user population who it is intended to serve, and their task goals. It is also necessary to consider typical task scenarios defining specific examples of people using the kiosk It is also important to understand the characteristics of the user population and the kinds of environment (physical and organizational) that the system will be located in, so that the design can reflect them.

2.4.2 Physical access

The height of a kiosk has to be placed so that it is convenient for both standing users and wheelchair users to access the keyboard. Wheelchair users may have to line themselves up alongside the kiosk and twist around to use it.

2.4.3 Encouraging use

A self-running demonstration is a good way to encourage users to approach the system and to find out what it can provide. Such demonstrations should be bright and eye catching, presenting short phases about what is on offer and typical screens. It should also be clear that the demonstration could be interrupted to start using it and how this can be done.

2.4.4 Language selection

It is desirable to provide multilingual interfaces to the system where languages other than the primary language are widely spoken in the local community. In order to choose the language on the system, instructions can be given in each language to select the appropriate option. If it is not possible to present all the information in different languages, then just the most critical information could be translated.

2.4.5 Introduction for instructions for using the system

Users will not have the time or inclination to read lengthy instructions displayed on screen before using a system. Therefore the instructions should be short and presented at each stage of the interaction. A good way of introducing users to the system is to present a free running demonstration of it, possibly with simulated interactions. A demonstration can show users what the system is about, what to expect when they start to use it, and how to interact with it. However such demonstrations should be short enough to be viewed by the interested user and allow them to start interacting with it before their interest diminishes.

2.4.6 Help

It is useful to provide help information throughout the system. It is therefore preferable to review each part of the system and decide what help may be needed at each stage. This can then be presented to the user as contextual help, which can be accessed with a single press of a button, labeled **HELP,** or with a question mark **(?)** This may also be coloured red to make it stand out.

2.4.6 Input to the system

The nature of the input used should be as consistent as possible throughout the task. If a new form of input must be employed at any point (e.g. moving from a keypad to a roller-ball) this must be highlighted with specific instructions at that point. User inputs to a kiosk system should be as simple as possible.

The user should only be required to make one input at a time, either selecting an option on screen, typing in a short text string, or highlighting a menu option and confirming the selection. If the user is entering a number or text string into a field, it is

necessary to ensure that the input position or focus on the screen is clearly highlighted. It is also important that the inputted characters are clearly distinguished from the system prompt by colour, font, and case. Mode of input can vary from application to application. Some of the examples are as follows:

1. **Keyboards and keypads**

   If a physical keyboard is required, it is preferable for the kiosk system to have a customized keypad with large clear keys and suitable key labels.

2. **Speech input**

   Speech input is rarely used on a public kiosk. The increase in the reliability of speaker independent speech recognition systems now makes it a possibility. The main problem is that pronunciation and speech intonation vary between people and when speaking, people tend to run words together. Speech systems work best when the user is familiar with them and can speak words distinctly.

3. **Touch screens**

   Touch screens provide a way of presenting keys or touch areas on screen, which can be changed for individual screens in the dialogue. Touch screen buttons are therefore a flexible solution for input via a kiosk. For each screen display, the relevant input buttons only, need be shown on the screen, thus simplifying the interface.

4. **Other input devices**

   The mouse is now a familiar input device to many people but can take a little time for novice users to become competent with them. Also a mouse can easily be detached and stolen from a public system. Web cam can be used to keep track of the user for security reasons or it can be used to provide live video to user itself for catching user's attention.

2.4.7 Output from the system

The output from the system is the main element of the whole system. The output can be information, a feedback or a warning through different modes such as visuals, sound, paper prints etc. we'll describe these elements in detail here:

1. Text

Textual information is the most common form of output. The presentation of information on a display should be kept as clear and simple as possible. Text should be no smaller than 16 point (preferably larger) so that members of the public with visual impairments can easily read it. The contrast between the text and symbols, and the background, should be high whether it is dark text on a light background or light text on a dark background.

2. Colour

Colours are used in interfaces frequently to enhance the visual appeal. Also colours can help in grouping the critical information displayed on the screen. However the use of too many colours can produce a confusing display. The number of colour codes should be kept within reasonable limits (4 or 5) if the user is to easily identify particular elements easily e.g. symbols or areas on a map. Here significant components of the display, e.g. buttons, input fields or icons should be made to stand out by putting distinctive borders around them or placing them within a plain area on the screen.

The following guidelines are also proposed in relation to colour:

- Total colour blindness is rare, but problems in discriminating red and green are common and suffered by over 6% of the male population (Gill, 1997).

- Large adjacent areas of red and blue should be avoided as users have difficulty focusing on these colours at the same time, causing visual fatigue (Helander, 1987).

- Use colours to structure the display and group categories of data, and to help identification (labels, entry fields, prompts).

- Use colour as an additional cue to help users recognize graphic symbols (RACE ISSUE, 1992).

- If text is to be used, it should not be colour-coded. Similarly text associated with graphical symbols should not be coloured (Clarke et al, 1996)

- Coloured text is preferable for short or temporary elements such as menu choices or messages rather than permanent elements such as long lines of text.

- Start by designing the display in monochrome. Then add colours, maintaining consistency in use, and test to ensure the resulting display does not create unexpected effects, (RACE ISSUE, 1992).

3. Use of language

Terms used by the system should be meaningful to the general public. Care should be taken while using terms related to computers, as they may be new to the user. While it is appropriate to use such terms when they are commonly used in the application area, it may be necessary to provide an explanation of them on a help page.

4. Icons

Icons provide an easily recognizable form of information element that can be understandable by people from different ethnicity. For a kiosk system icons must be understandable without too much explanation, and distinguishable from other icons on screen. Simple icons are preferable to complex digitized images. It is important to test out any icons used by the system to check that they are clearly understandable. It is however very difficult to design icons that are self explanatory to all users. One solution is to place the meanings of icons within the system introduction, on a help page, or as short labels under the symbols themselves.

5. Feedback

The feedback from the system should be very quick and shouldn't take more then 50 milliseconds. If it will take more then 2-3 seconds, user may feel that some fault has

occurred. If some process is taking more time then animated status icon should be displayed. The feedback can be of any visual animation or a small audio clip.

6. Images

Photographs or images are used to represent factual and documentary information. They should therefore be used to reproduce things as close to reality as possible. Coloured images appear livelier and if showing, for example, people or landscapes, it is natural to use colour. Black and White images are suitable for showing a concept or theme in general terms, or to ensure that an image does not distract the user too much from the text. Simplifying or emphasizing certain details on an image requires some graphic design skills.

7. Graphics

Graphics (or diagrams) are good for schematic representations, expressing ideas, or futuristic objects. Where an image is of poor quality, and contains a certain amount of detail, a graphic may be clearer than a photograph. Graphics can be used to show things that do not exist in reality, or can be used to simplify a picture or accentuate or highlight essentials. A graphical expression should be as simple and pure as possible. Sometimes black and white graphics with high quality gray shades are more legible than too colorful an illustration especially as colour displays do not always render all the colours as intended. Graphical coding of objects can be effective; for example, different shaped elements representing components on an electrical circuit, colours to show political boundaries on a map, line lengths and angles to represent wind speed and direction, etc.

8. Speech Output

There is a growing use of speech output to provide guidance, to supplement screen information, or to transmit information as part of a multimedia presentation Speech should be used sparingly when the system is in a public place to avoid sound pollution. Having a visible speaker can add impact to the voice output and as an '*interface agent*' can point to items on screen.

2.4.8 Navigation and structure

1. **Navigation**

   The user should be provided with some basic controls for navigating through the system.

   Examples of useful controls that may be considered are:

   - *Start, Finish, and Restart* - Start or finish interacting or exit and start again.
   - *Step back or Go back* - Go back to the previous screen or step in the interaction.
   - *Next page, previous page* - Step through information screens.
   - *Enter or OK* - Complete keyboard input, select menu option or acknowledge system message.
   - *Cancel or Exit* - Cancel or exit from the current part of the system.

2. **User Interface Structure**

   Kiosk system should present a clear and simple structure to the user. By doing this, the user will feel more confident in moving or navigating through the system. The system should have a single starting point, which the user can return to when they wish.

   The interface should covey a clear structure to the user such as:

   - A sequence of screens where the user makes a selection at each stage in order to reach some useful information.
   - A set of on-screen objects that, when selected, present information in a window, dialogue box or speech bubble.
   - A network of screens, which allow the user to browse randomly supported by an overview map to show paths.

Each screen should also have a clear title, which is short and distinctive. This will help the user maintain an idea of their location within the system. Hypertext links which allow the user to jump around within a network structure are appropriate for special applications where the user simply wishes to browse through screens looking for information of interest. However users are unlikely to form a good mental picture of the structure and so may find it hard to navigate with certainty.

3. Menus

Menus provide an easy means of input for kiosk users since they simply select the input they require from a list of options. Make sure that each menu option is concise and clearly worded so that the user has a good idea of what they will get when making a selection.

General menu design guidelines are as follows:

- Ideally a maximum of 12 options should be presented on one menu.
- Menu lists require careful structuring, such as by alphabetical order, the most common options first, or in the logical order in which they will be selected (e.g. search, display, print). Blank lines between groups of items in a menu can help emphasize the structure.
- Abbreviations should be avoided in menu options unless well known to the public.
- Technical or computer jargon in menu options should be avoided.
- Splitting a menu over two pages, possibly by having two columns of options on one page may create problem in navigation.

2.5 High precision touch screen interaction

This is brief review of research done at IBM by *Albinsson and Zhai* in techniques for interacting with touch screen at high precision.

Interaction over the touch screen is the most "Direct" form of interaction in HCI. The zero displacement between input and output, control and feedback makes touch screen very intuitive to use, particularly for novice users. Besides its directness, touch screen also have special limitations. First, the user's finger, hand or arm can obscure the screen. Second, human finger has a very low resolution. It is difficult to point at targets that are smaller then finger width.

The goal is to design interaction tool allowing pixel level pointing in a fast and efficient manner. They propose two techniques; *Cross Keys* and *Precision Handle*. Along with a *Zoom Pointing* which was used earlier.

For pointing a pixel sized target, it is possible to use zooming to enlarge the information space to a scale in which one can comfortably point at a target with a bare finger. The method applied for zooming is known as *bounding box zoom*. With this approach user first activates the zooming mode and then draws a bounding box that encloses the area to be zoomed in. When the user releases the box, the system zooms and pans to the selected area. Thereby user can easily point at the target at an easy scale.

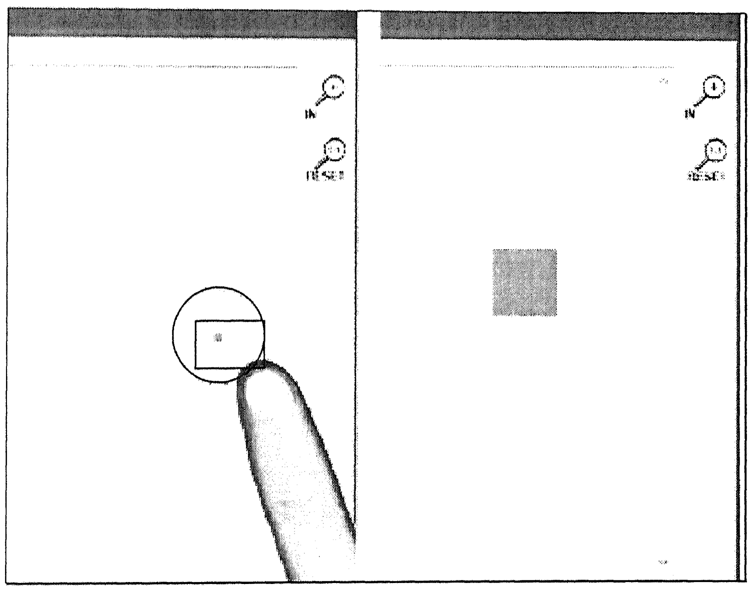


Figure 2.4.1 Zoom Pointing Method

The second method *Cross Lever* presents two crossed lines when user first taps on the screen. The intersection between these lines indicates the point to be selected, which can be controlled by moving the two "Rubber Band" Lines separately. Each end of the line has a handle, that can be dragged and, making the line longer or shorter. As can be seen in figure 2.4.2 the user deploys the Cross-Lever as close as possible to the highlighted target. To adjust the intersecting point to within the target the user drags the uppermost handle upwards. The other two handles do not move. The smaller circle surrounding the intersection point is the activation area of the Cross- Lever

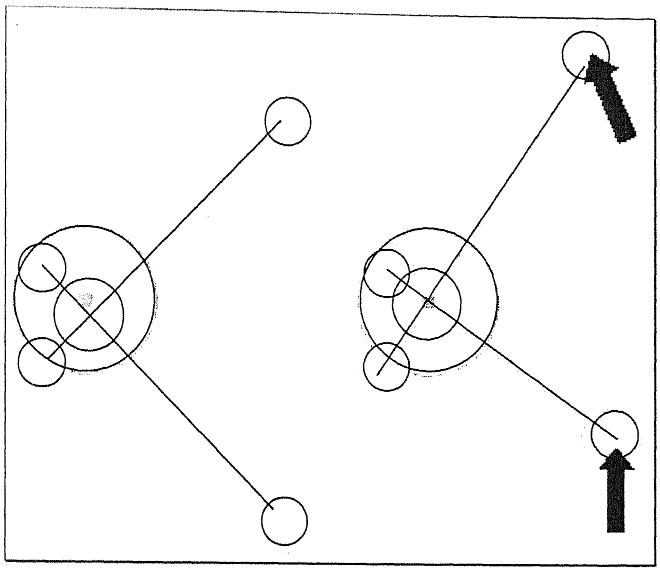


Figure 2.3.1 Cross-Lever Method

One another method called *Virtual Keys* techniques has another way to achieve the target. *Virtual Keys* uses four graphical arrow keys and an activation key, all positioned on a side panel, to control the position of cross hair cursor (figure 2.4.3). The typical sequence is to fist deploying the cross hair by touching very near to the target, adjusting it using arrow keys and then tapping the activation key.

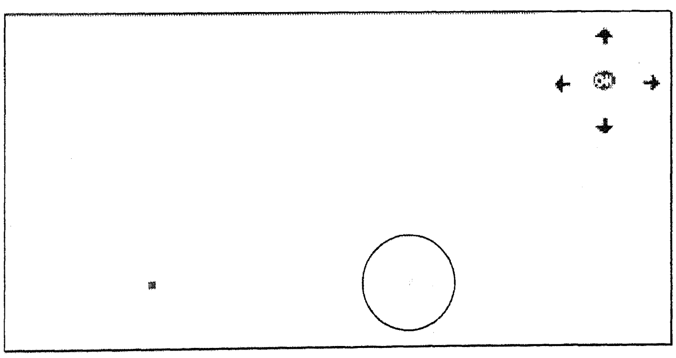


Figure 2.3.1 Virtual Key Method

In continuation with the previous two methods, a new method has been suggested called *cross keys*. This method inherits the concept of Cross-Lever and Virtual-Keys methods. The cross hair contains four arrow keys at all the four ends. These keys act like Virtual Keys. The first tap on the target deploys the cross hair with the arrow

keys (figure 2.4.4) and if adjustments are needed, tapping on the arrow keys can move cross hairs in the similar fashion as of Cross-Lever technique. Once on target, user can tap the center circle for activation.

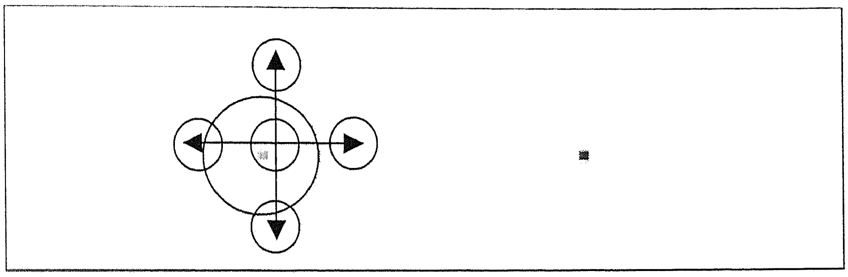


Figure 2.3.1 Cross-Key Method

These methods are the primer techniques, which form a basic platform for the further development of high precision techniques.

Chapter 3

User Interaction with Input Elements in Touch Screen Interfaces

3.1 Abstract

Interaction with the touch screen using finger touch for information retrieval in public information system is becoming a widely used application now days. This work explores the study of user's interaction and behaviors over a touch screen using a small interactive game. Our goal is to decide upon the parameters for input element such as Button, scroll bars, check box etc. on the basis of results generated by the game. The further idea is to design intuitive based interfaces so that public information systems can be made easy to navigate and work upon.

3.2 Introduction

Touch screen interaction is new field of research and becoming very popular in many applications of *Information and Communication Technology (ICT)* systems, such as public information kiosks, ticketing machines, bank teller machines etc. This is the direct approach of interaction as the control and vision area are same and user can use his finger or a stylus pen to activate controls. The widely used approach is finger touch instead of stylus, although finger has much less resolution in relation to the stylus pen. A stylus is a

much "sharper" pointer than a finger tip, but its resolution may still not be as good as a mouse cursor.

These interfaces have many advantages. First, due to its control surface overlaid over the display area, no additional input devices are required. Second, these monitors are very robust compared to any other input device such as mouse and keyboard. The basic disadvantages includes less freedom to design input controls, due to low resolution of finger, accuracy is not as good as normal input devices. User's finger, arm and hand can block the vision while navigation through he screen.

While designing the interfaces it is very essential to study user's reaction and their behaviors while interacting with touch screen interface. Different people behave in a different manner with a given system. Most of the user use either of their hands so it is necessary to consider left handed and right handed people. Some user use single finger and some of them use multiple fingers and some of them even use their thumb for selection and clicking the buttons etc. also users react in a different way for different type of input elements such as different size, shape, color and texture of the buttons, different combination of foreground and background colors, variation in spacing between buttons.
For that purpose we proposed a game application which can collect data while the user is interacting with that game. That data can be used for analysis of different parameters for the input elements.

3.3 The Game Application

The game is based on the simple logic of random prompt for selection of input elements. The game has 9 buttons arranged in a 3x3 matrix form. At a time one button highlights and uses has to catch that before another button became active. The user has to catch the highlighted button and his success and failure for touching that button will be stored in a remote database in the form of **HIT** and **MISS**. The game has 8 different parts and each part presents a new similar game and hence a new experimentation.

The game starts with an introduction screen (Figure 3.1) with a brief description about the game and instructions for using the touch screen. The first screen consists of only two rectangular buttons to reduce the confusion for first time users. An animated arrow key points towards the start of game. The start button is green colored which drives the user to accept it. The another buttons is red colored and kept low in the contrast which shows that button is not to accept but to decline the current scene. After selection of green button, user enters into first part of the game.

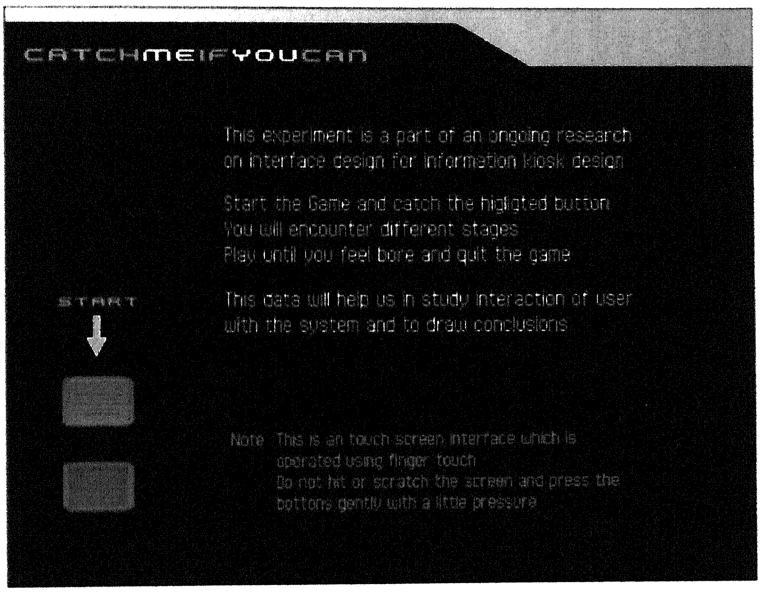


Figure 3.3.1

Game Part 1

This part consists of 9 rectangular buttons over a black background and user has to select the highlighted button. These buttons are highlighted randomly so this is difficult to predict the next button to catch. After a predefined time the game automatically enters the next level. On the top right corner, total no. of HIT and MISS for highlighted buttons can be seen. User can play continuously until he feel s bore and at that time he can quit by touching red button which is active in this level and green button is dim showing its inactive nature. (Figure 3.2)

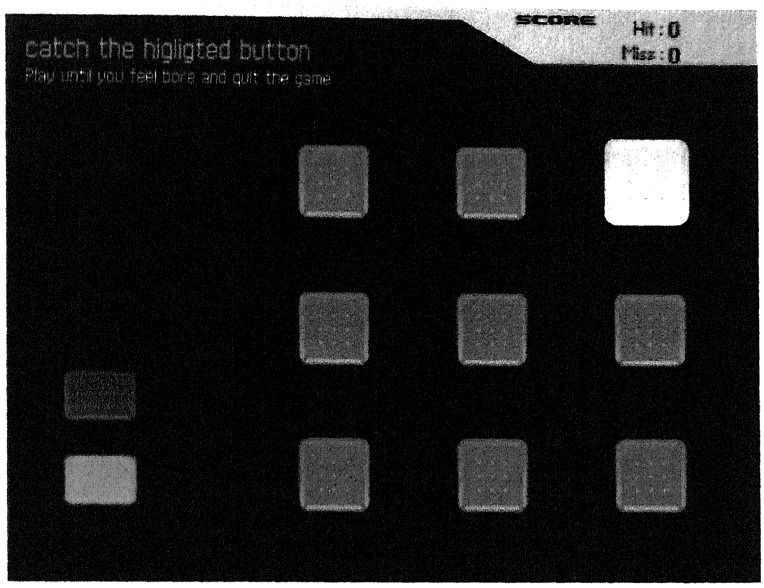


Figure 3.2

Game Part 2

This part is very much similar to the part one, the only difference is the background of the array of buttons. The background is 50% gray and the game proceeds in the similar fashion. (Figure 3.3)

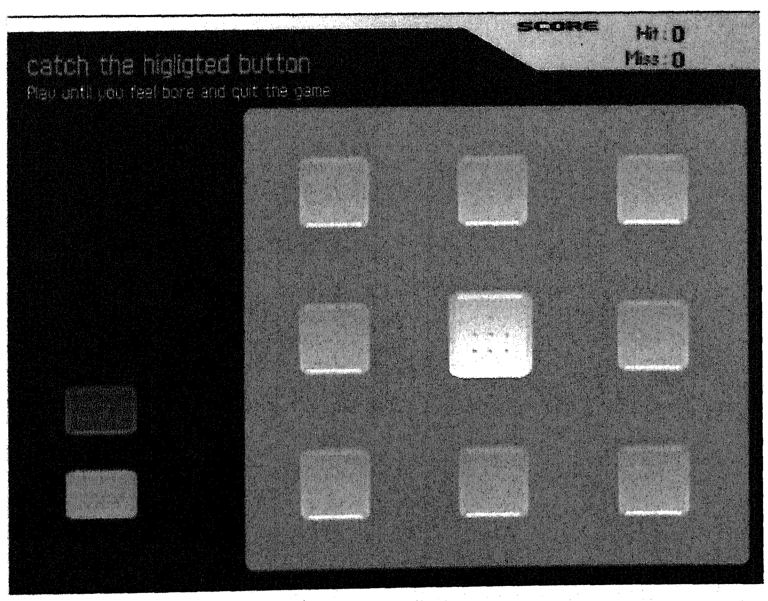


Figure 3.3.3

Game Part 3

This part is again a part of the same series; the only difference is the background of the array of buttons. The background is white and the game proceeds in the similar fashion. (Figure 3.4)

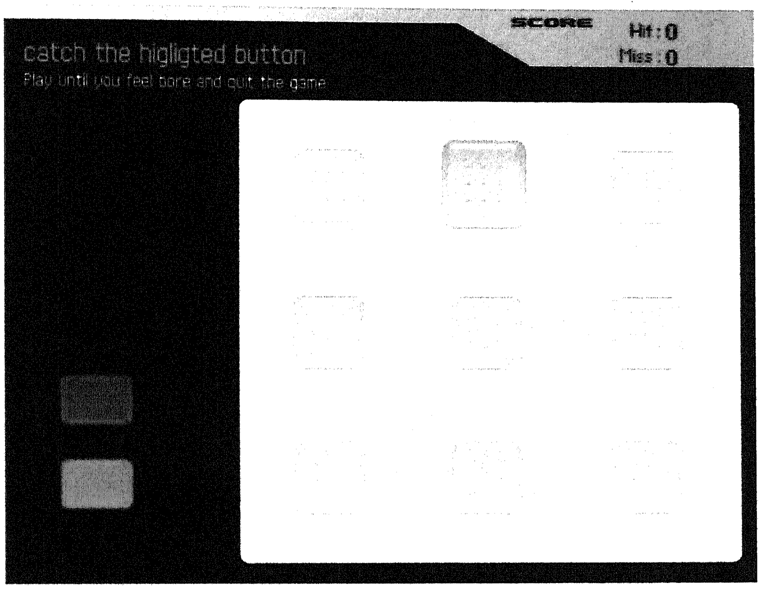


Figure 3.3.4

Game Part 4

This part displays equilateral triangles and game follows the same rules. (Figure 3.5)

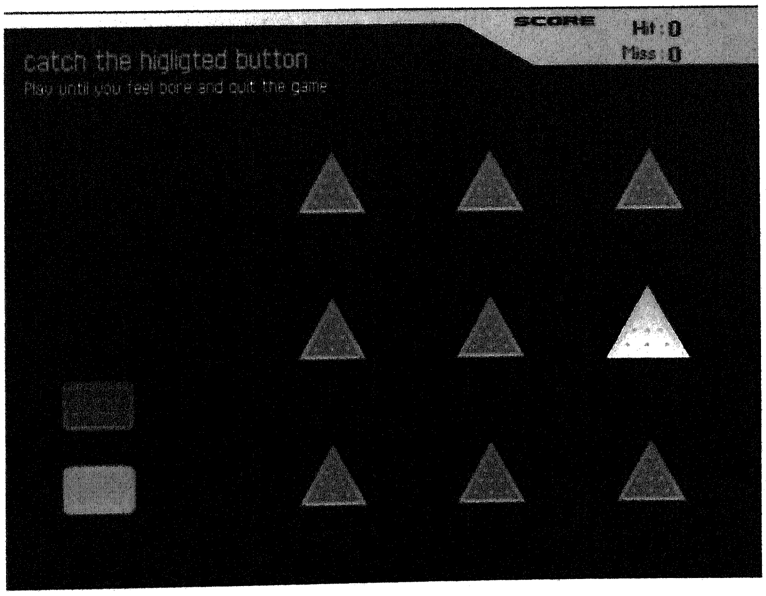


Figure 3.3.5

Game Part 5

This part has a similar array of circular buttons with a diffused gradient. (Figure 3.6)

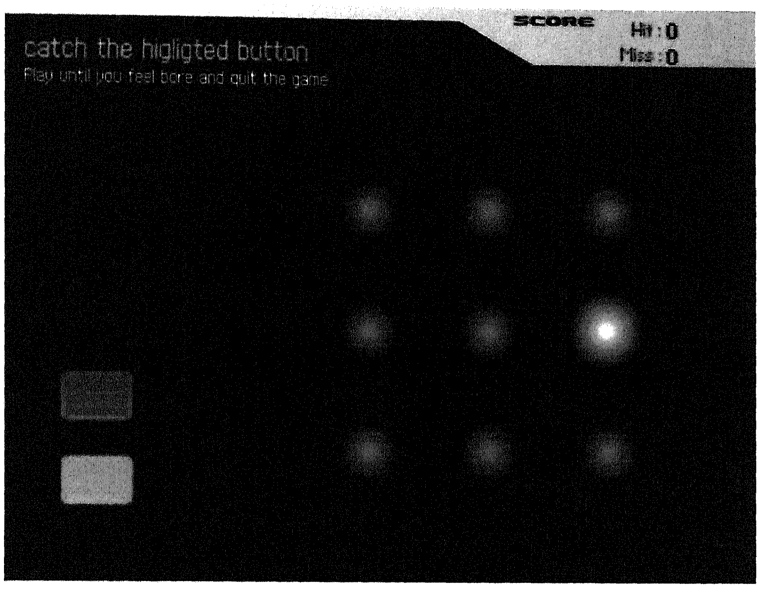


Figure 3.3.6

Game Part 6

This Part is the continuation of the last part but the distance between the elements has been reduced.

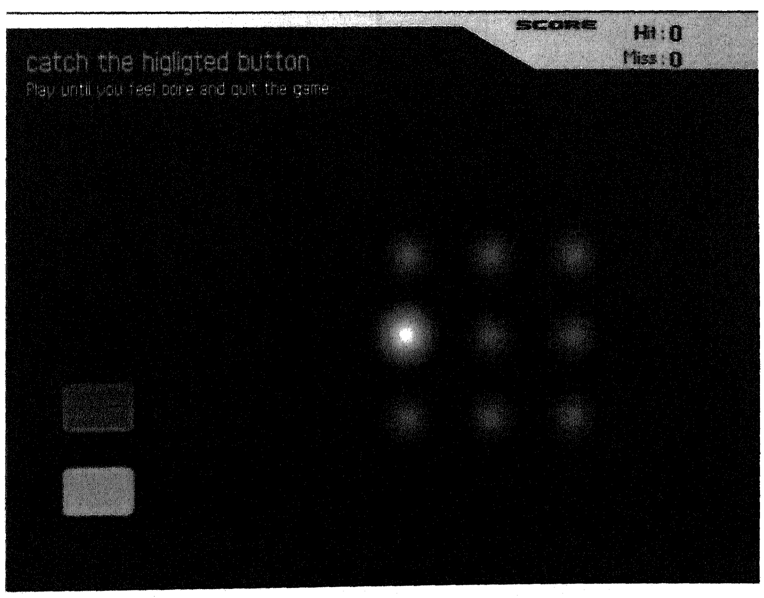


Figure 3.3.7

Game Part 7

This part consists of mixed shapes and similar random highlighting of the buttons. (Fig. 3.8)

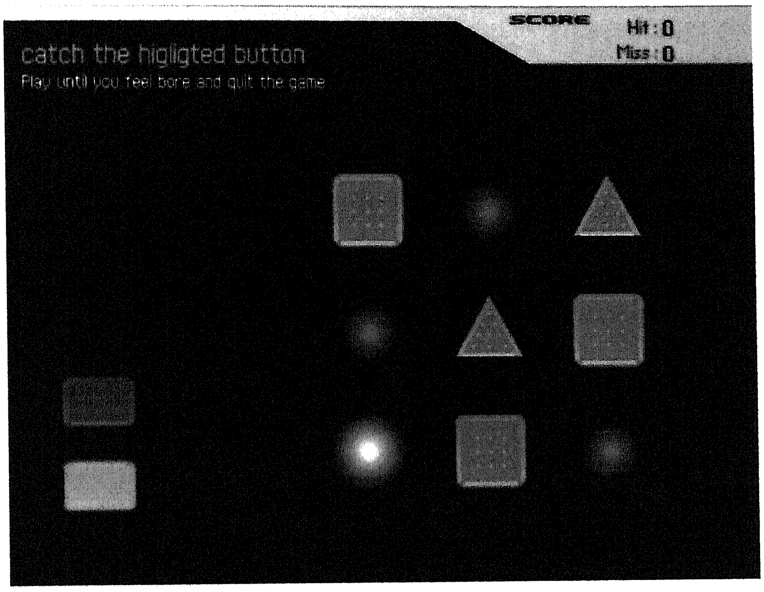


Figure 3.3.8

Whenever user quits the game after pressing red button, it updates the database simultaneously and again user comes to the very first screen of the game.

This application follows the following algorithm.

Game Algorithm

Start Main

If (GreenButton Click = True)

Call Function (SelectLevel)

End If

End Main

Function Selectlevel

Generate random number between 1 to 7

Goto Game (GameNumber)

End Function

```
Function game (GameNumber)
    Select GameNumber
            Case 1 : Start game1
                Do while (time>= 7 sec.)
            Generate random number between 1 to 9
                HighlightButton (Random number)
                If (SelectedButton = HighlightButton)
                    Increment HitCount
                Else
                    If (SelectedButton = RedButton)
                        Update database for Hitcount and Misscount
                        Quit the game and return to the first screen
                    Else
                        Increment MissCount
                            End If
                End If

                End While
                Update database for Hitcount and Misscount
                Call Function (SelectLevel)
                    Break

            Case 2 : Start game1
                    Do while (time>= 7 sec.)
            Generate random number between 1 to 9
                    *
                    *
            Case 3:
                    *
                    *
    End Select
End Function
```

3.4 The Experimentation

65 volunteers participated in the experiment. The following data was collected from them before experimentation.

Mean Age	23 Yrs
Total Males	60
Total Females	5
Persons familiar with the GUI	58
Persons familiar with the Touch Screens	42
Right Handed	51
Left Handed	14

The main experimental apparatus was a commercial CRT based 14", *5 wire Resistive Touch screen*, made by MicroTouch™ 3M. Its active display area was 255 x 191 mm and was set at 1024 x 768 pixels resolution, with pixel size of 0.25 x 0.25 mm. Its refresh rate was set to 85 Hz. Activation force using finger < 50 gm with 5/8 diameter finger. The screen was tilted to 40° to minimize fatigue.

The volunteers were given the freedom to explore the interface with some brief guidelines in the start screen to describe about touch screen and interaction with the interface. The interactive game was not having any time limit, so volunteers spend time according to their convenience.

The following data was continuously updated after completion of every stage.

- Automatic serial number for each experiment
- Total number of successful hits
- Total number of wrong hit
- Total duration of that stage of game

The data was stored dynamically in MS Access 2000 database using *Active Server Page* and *Flash MX* integration.

The following code in ASP was used for updating database.

```
<%@language = "VBScript" %>
<%

strHIT = Request.Form("HIT")
strMISS = Request.Form("MISS")
strOPR_TIME = Request.Form("OPR_TIME")
strEXP_NO = Request.Form("EXP_NO")

MyPath=Server.MapPath("db1.mdb")
    Set conn = Server.CreateObject("ADODB.Connection")
    conn.Open "Driver={Microsoft Access Driver (*.mdb)};" & _
    "DBQ=" & MyPath

SQL = "INSERT INTO GAME2 (HIT,MISS,OPR_TIME,EXP_NO) VALUES
('"&strHIT&"','"&strMISS&"','"&strOPR_TIME&"','"&strEXP_NO&"')"
conn.Execute(SQL)
%>
```

3.4.1 Data Collection and analysis

The data collected form each stage of the game was the analysed to draw inferences.

(i) Data from Game Part 1

Total number of data	= 138
Total number of successful Hits	= 892
Total number of unsuccessful Hits	= 415
Hit to Miss ratio	= **2.149**

(ii) Data from Game Part 2

Total number of data = 127

Total number of successful Hits = 1619

Total number of unsuccessful Hits = 741

Hit to Miss ratio = **2.184**

(iii) Data from Game Part 3

Total number of data = 127

Total number of successful Hits = 2230

Total number of unsuccessful Hits = 927

Hit to Miss ratio = **2.405**

(iv) Data from Game Part 4

Total number of data = 95

Total number of successful Hits = 621

Total number of unsuccessful Hits = 142

Hit to Miss ratio = **4.37**

(v) Data from Game Part 5

Total number of data = 93

Total number of successful Hits = 1076

Total number of unsuccessful Hits = 201

Hit to Miss ratio = **5.35**

(vi) Data from Game Part 6

Total number of data = 97

Total number of successful Hits = 917

Total number of unsuccessful Hits = 268

Hit to Miss ratio = **3.421**

(vii) Data from Game Part 7

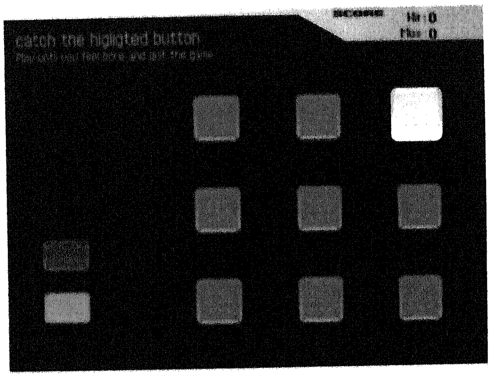
Total number of data = 65

Total number of successful Hits = 384

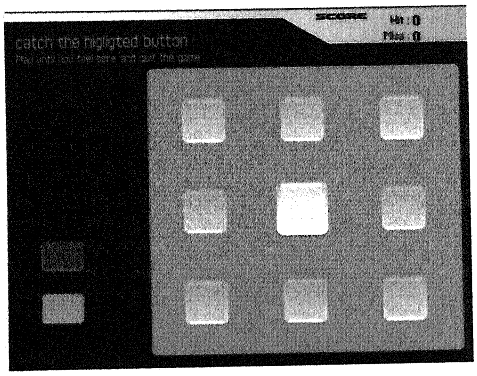
Total number of unsuccessful Hits = 86

Hit to Miss ratio = **4.465**

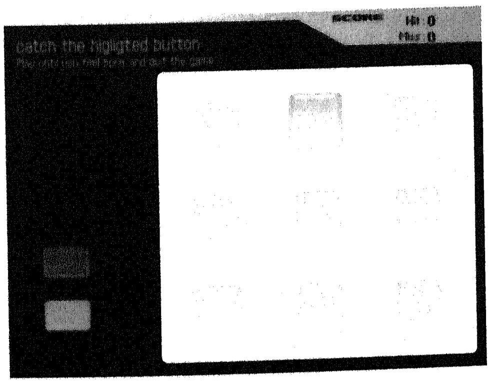
3.4.2 Comparative analysis of data from all stages.



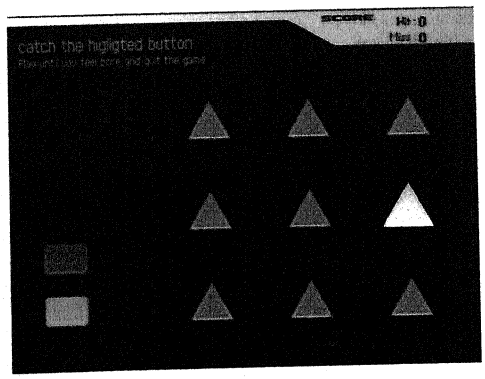
Part 1: Hit to Miss ratio = **2.149**



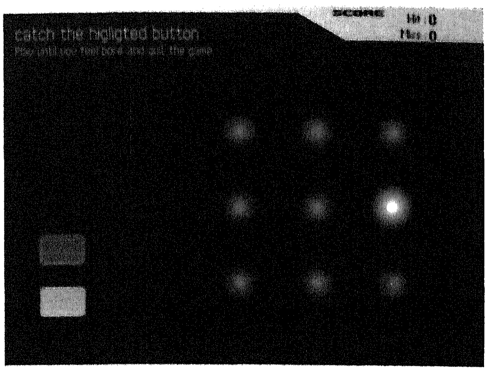
Part 2: Hit to Miss ratio = **2.184**



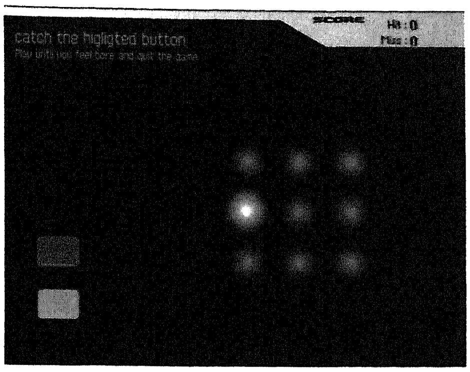
Part 3: Hit to Miss ratio = **2.405**



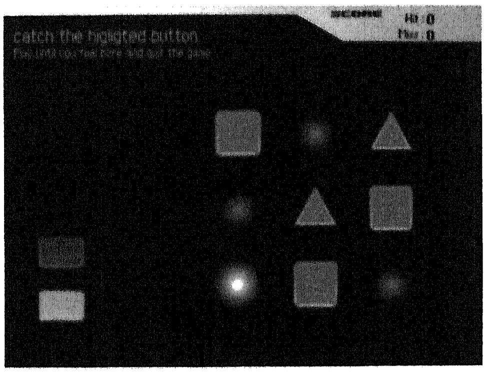
Part 4: Hit to Miss ratio = **4.37**



Part 5: Hit to Miss ratio = **5.35**



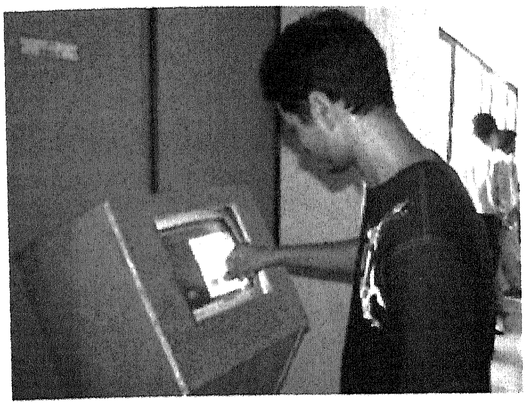
Part 6: Hit to Miss ratio = **3.421**



Part 7: Hit to Miss ratio = **4.465**

3.4.2 User study and personal observation.

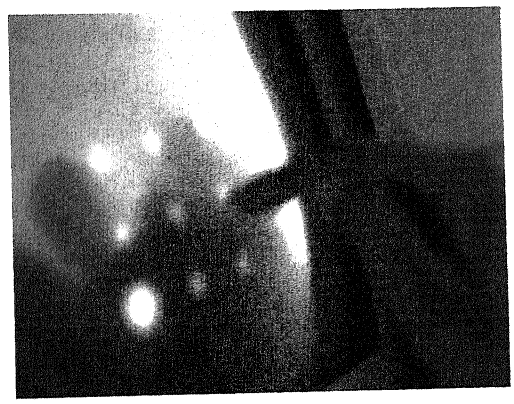
During experimentation, users were asked to play the game, without giving any guidelines for using touch screen. They were then observed carefully for their behaviour and way of interaction with the touch screen. Some of the users were interviewed in details regarding the problems in the interface. We can see some of the pictures of the users interacting with the system in Figure 3.4.1.



A user navigating the interface

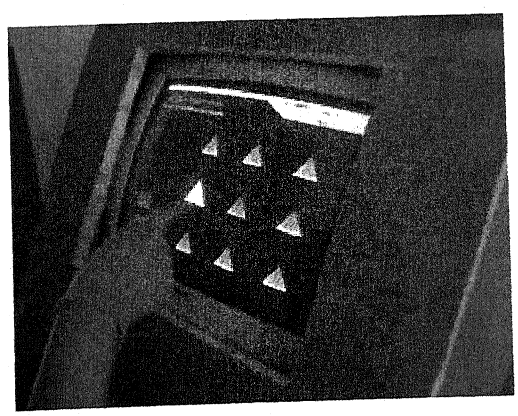
Some users use their thumb to navigate the interface

Using finger touch



User trying to hit the screen

Both the hands in action for navigation



Precision Touch

Figure 3.4.1 User's study over touch screen interaction

3.5 Inferences and Solutions

After analysis of data collected from the experimentation and personal observation, the following inferences have been drawn.

3.3.1 Inferences from data analysis

(i) User navigates faster, with contrasting combination of background colour and button colour.

(ii) User navigates faster, in case there is less spacing between the buttons but the accuracy level goes down simultaneously.

(iii) User navigates slower in case there is more spacing between the buttons but the accuracy level increases simultaneously.

(iv) User navigates efficiently if interface elements maintain a harmony in colour and shapes.

3.3.2 Inferences from personal observation

(i) Triangular buttons seems to be most comfortable in large button spacing.

(ii) Sharp edges of buttons slow down the navigation speed.

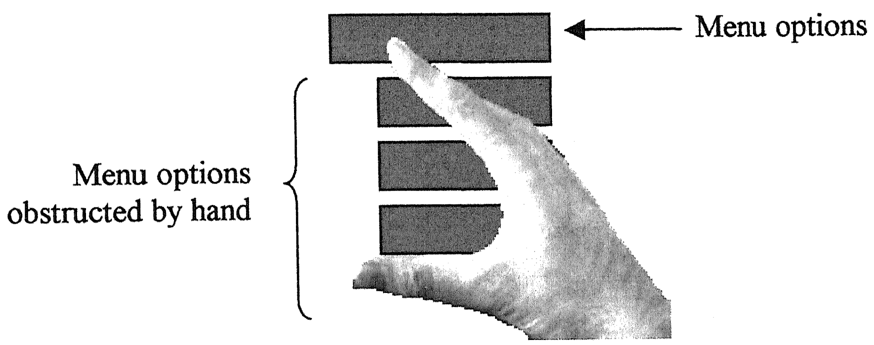
(iii) Users feel comfortable using both the hands while navigating.

(iv) Hands obstructs many elements, hence creates problem in navigation.

(v) Some users tap over the screen many times to select a button.

3.3.3 Solutions for hand obstruction over the screen during navigation.

One of the biggest problems while navigation over a touch screen interface is the obstruction created by our own hand. For this sake, the menus and navigation elements can be arranged in such a fashion so that user can comfortable access all the options. As can be seen from figure 3.5.1, how conventional menus creates problem in navigation.



Solution

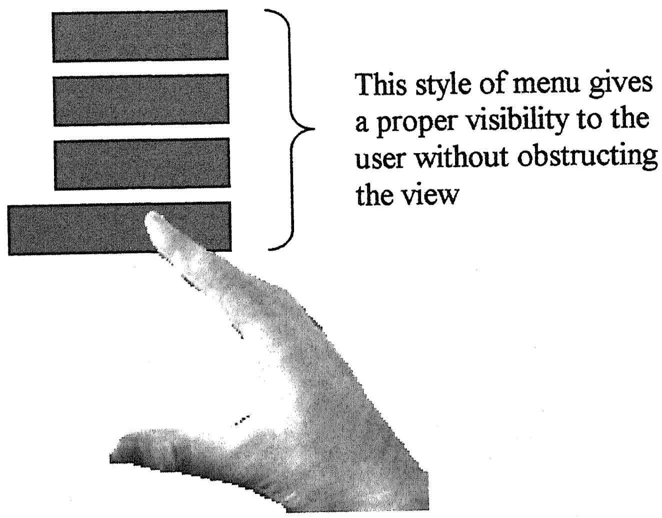


Figure 3.5.1 Hand obstruction over the touch screen

Another problem comes whenever there is an option for submenu. As can be seen form figure 3.5.2 the submenu can be arranged on the extreme sides of the screen to gives a better visibility.

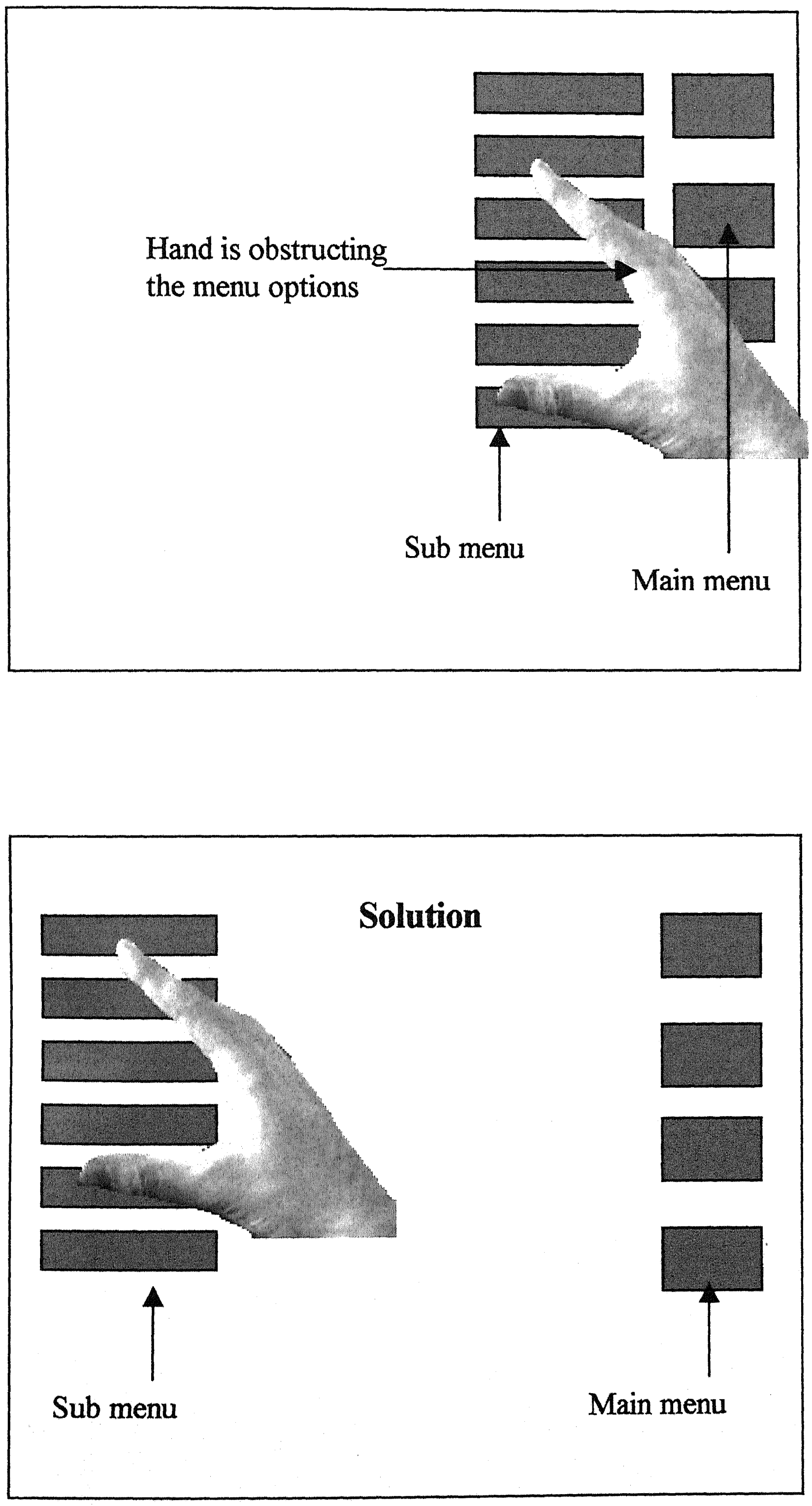


Figure 3.5.2 Hand obstruction over the touch screen in menu systems

Chapter 4

User interface design for a touch screen based information & navigation system for an academic campus

4.1 Introduction

Indian Institute of Technology Kanpur has a huge campus on 1055 acres of land. Campus Amenities includes Academic area, Staff residential area, Students hostel area, recreation centers, market etc. Although the institute has many signages but new comers and visitors always find it very difficult to locate the desired location mainly in academic area. Also the visitor's category includes every class of people and majority of people face this problem. So there is a need to design and develop a system, which can provide the general information about the institute as well as provide an interface to the visitor to locate desired locations.

4.2 Need statement and problem formulation

To design a navigation and information system for IIT Kanpur to locate various important places within the campus using touch screen interaction techniques.

4.2.1 Target group

IIT Kanpur was chosen because people from different parts of the country and culture can be targeted here. IIT Kanpur provides a very good platform to study and conduct survey upon people from different educational background. It is very easy to target every class of people including, new students, visitors from rural and urban areas etc.

4.2.2 User research

A user survey was conducted to find out the basic problems user generally face while coming to the campus for the first time. Some of the problems were very common among new community of IIT Kanpur Campus. After conducting the user survey, some of the problems were chosen to solve and to decide design guidelines for designing the interface.

Some of these problems are as follows:

(i) It is very difficult to reach a particular destination in academic area without asking somebody.

(ii) Many people in a hurry cannot find bus schedule.

(iii) Toilets and canteens are not easily accessible

After observing the user data and depth interviews, it was observed that:

(i) There is a need to design an information system, which can provide an easy approach in finding the desired destination mainly in the academic area.

(ii) The system should be simple enough to motivate a novice user to use it.

(iii) The design should be intuitive and should solve the basic queries of the users.

4.3 Design preliminaries

Some of the implementations decided to implement in the system are as follows:

(i) A navigation tool to access important places within the academic area campus.

(ii) Similar tool to access public amenities such as food points, toilets, phone booth etc.

(iii) Next available bus to various places in Main Kanpur city.

(iv) Date and time tool.

(v) Basic information about different departments and centers.

(vi) User data entry form.

A basic prototype was prepared for testing the functionality of the navigational map. Since the mode of input was touch screen, all the element chosen were click able buttons.

4.3.1 Icon selection

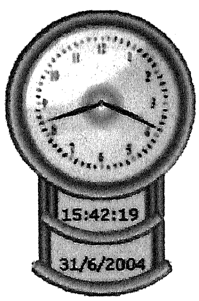
Icon selection was the most important part of the whole project. Since many people may not understand the long English phrases or guidelines, it is very necessary to design graphical icons for them to interact with the system easily. The icons selection was based on :

(i) The user mental model with the touch based interfaces.

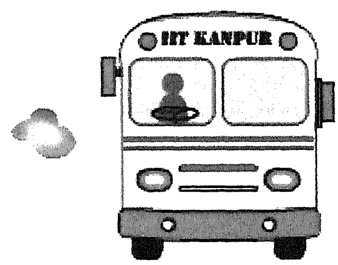
(ii) The users familiarity with the elements in the icons.

(iii) Users motivation.

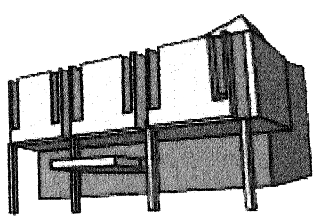
The following icons were designed:



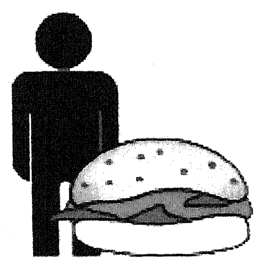
A clock



IIT Staff Bus

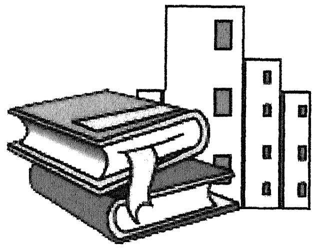


Centers and buildings in the campus

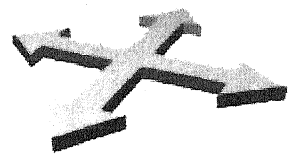


Public amenities

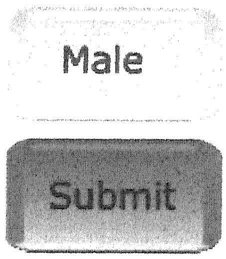
Figure 4.3.1 (a) Icon Set for the Interface



Public amenities



Navigation



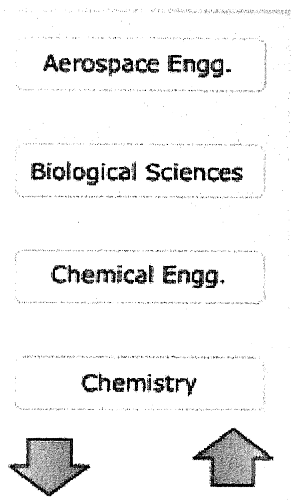
Buttons

Brand name for Navigation Kiosk

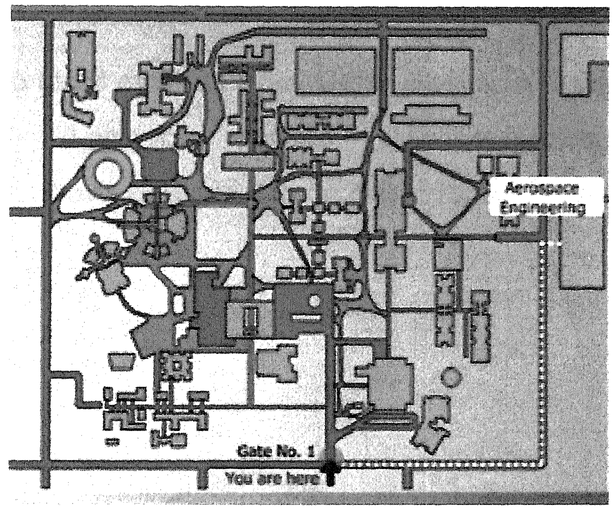
Figure 4.3.1 (b) Icon Set for the Interface

4.4 Design of interface and interactive tools

Here is a brief description of interactive tools, which helps in the navigation of academic area map. The below shown menu is used to select desired destination and the result showing the shortest path is displayed in the map. We can see the control for scrolls are given at the bottom. Providing scroll controls at the bottom prevents the obstruction of hand can provide full visibility of the menu options.



Menu for selecting departments



IIT Kanpur map

Figure 4.4.1 Menu and Map

User proceeds through the interface as follows:

1) Welcome Screen

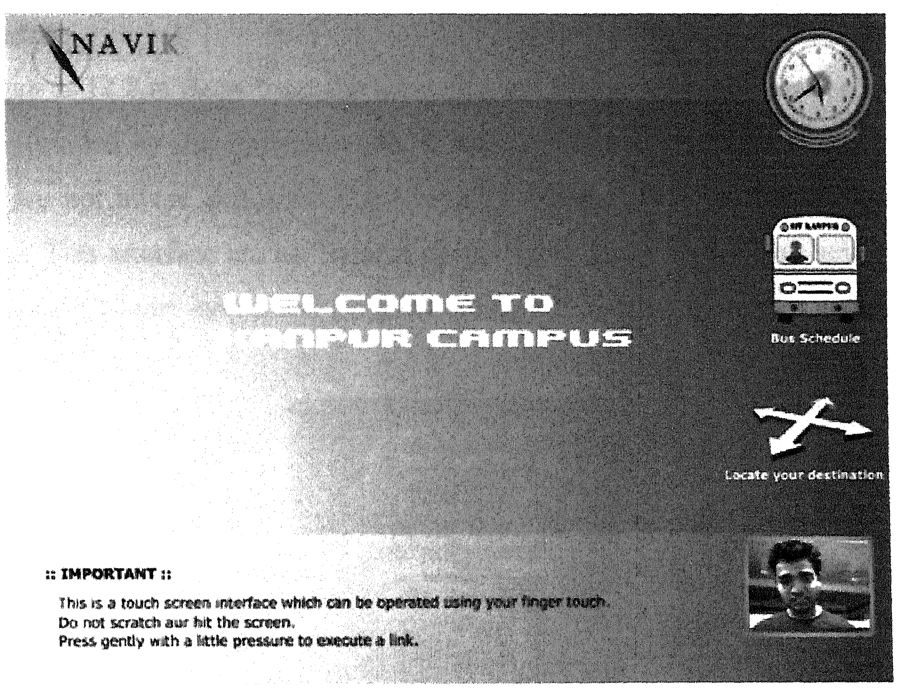


Figure 4.4.2 Welcome screen

2) Clock

It has been observed that a user tries to touch each and every visible element over the screen. In that case every active element should give some response or acknowledgement. In case of clock on the top-right corner, it shows time and date in digital format if user touches it.

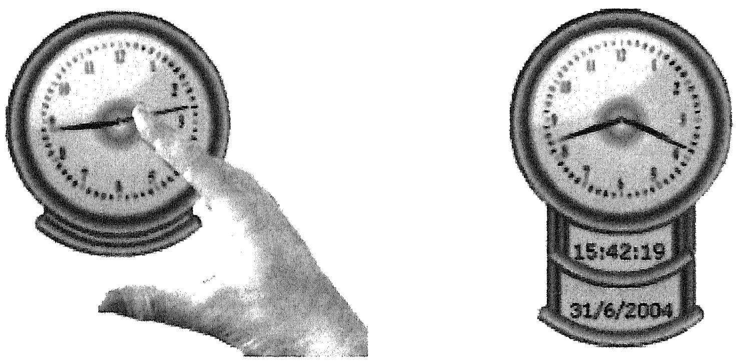


Figure 4.4.3 Response of clock

3) Bus Schedule

IIT Kanpur is 17 Km away from the main city and IIT community is dependent on the bus service provided by the administration. It was found that most of the new people in the campus are not aware about the bus schedules and they face problem in looking for the schedules. This interface has an element on the main screen that shows am icon of the bus. If a user touches that icon it will display a listing of main places in the Kanpur city.

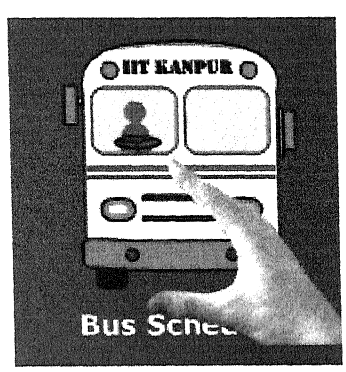


Figure 4.4.4 Icon for IIT Kanpur bus schedule

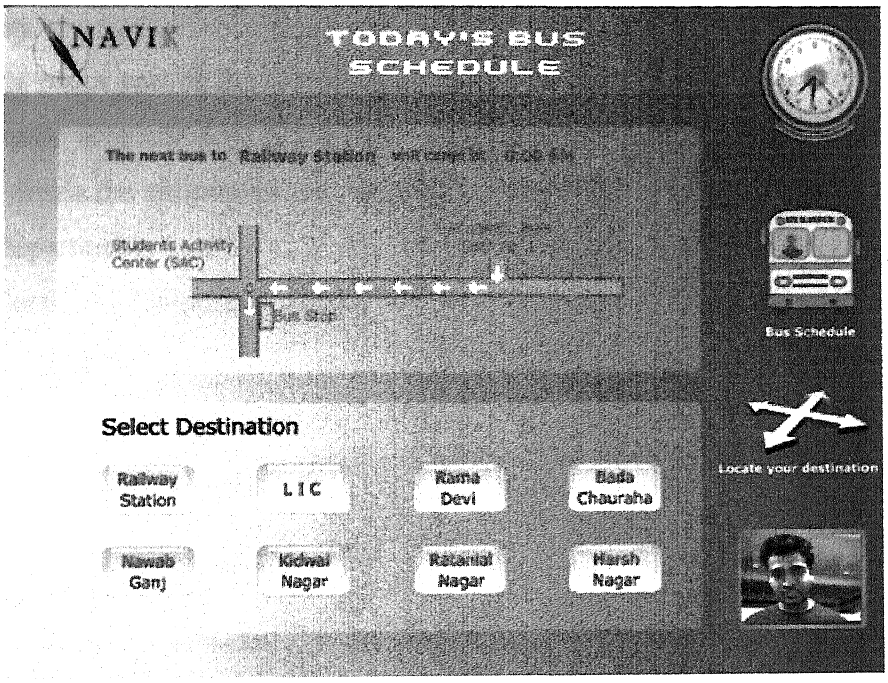


Figure 4.4.5 Interface Showing the schedule of buses

5) Information about the system

The icon for NAVIK shows the brief description about the system and its' working.

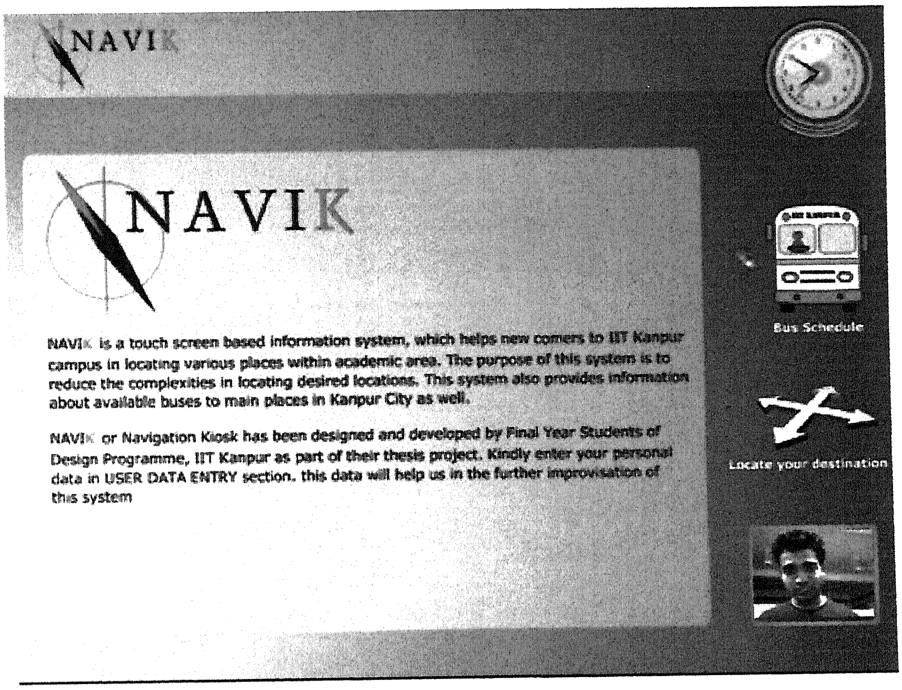


Figure 4.4.6 Interface showing the schedule of buses

6) Navigation

This is the major part of the complete interface. This section deals with the navigation of the academic area campus. Since there are many places in the campus, it is very necessary to divide the information into segments. There are three main sections;

(i) Departments

(ii) Centers and important places

(iii) Public amenities

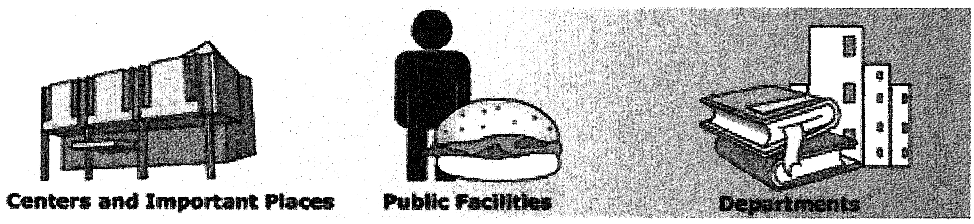


Figure 4.4.7 Three segments for navigation

7) Departments

The menu on the left contains the listing of all the departments and after clicking the option it shows the way from Gate-1 to the destined place in yellow dotted lines

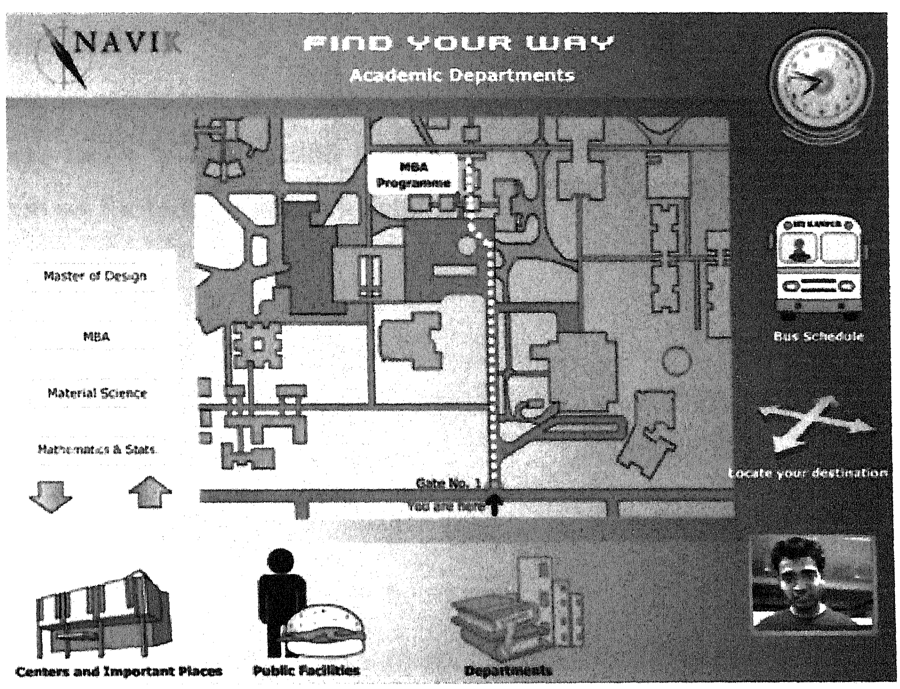


Figure 4.4.8 Department search

7) Centers and important places

This section is similar to the departmental search. It gives the option to find centers, important buildings and places within the campus.

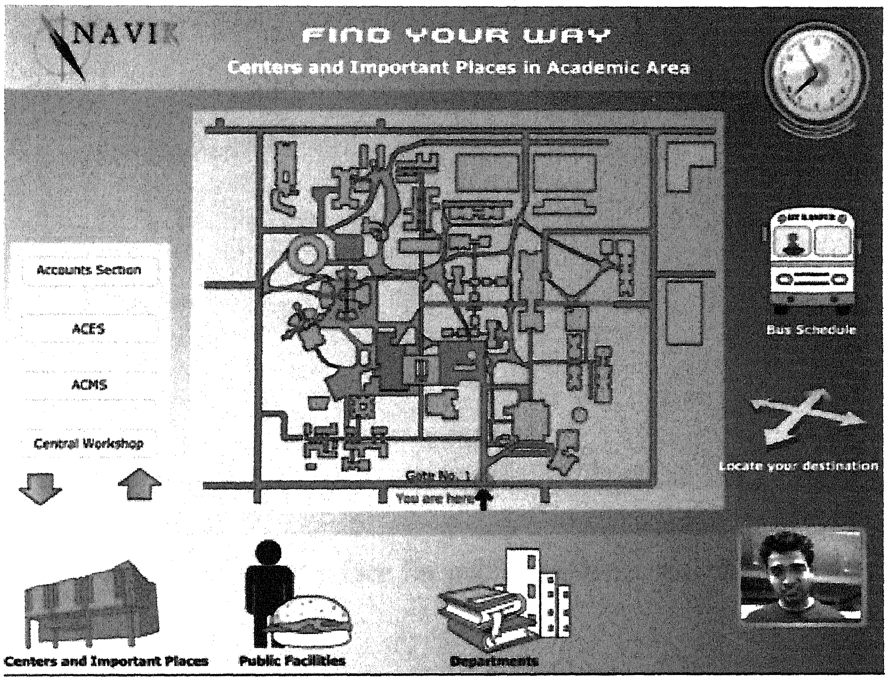


Figure 4.4.9 Centers and important places in the campus

7) Public amenities

This section provides a quick access to the public needs such as Food Points, Toilets etc. The sub menu in this section is different from the last two sections. There is a separate icon set for food point and toilets.

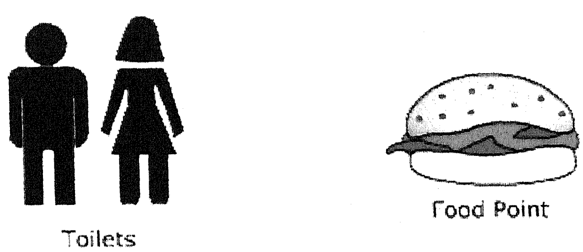


Figure 4.4.10 Icon set for Toilet and food points

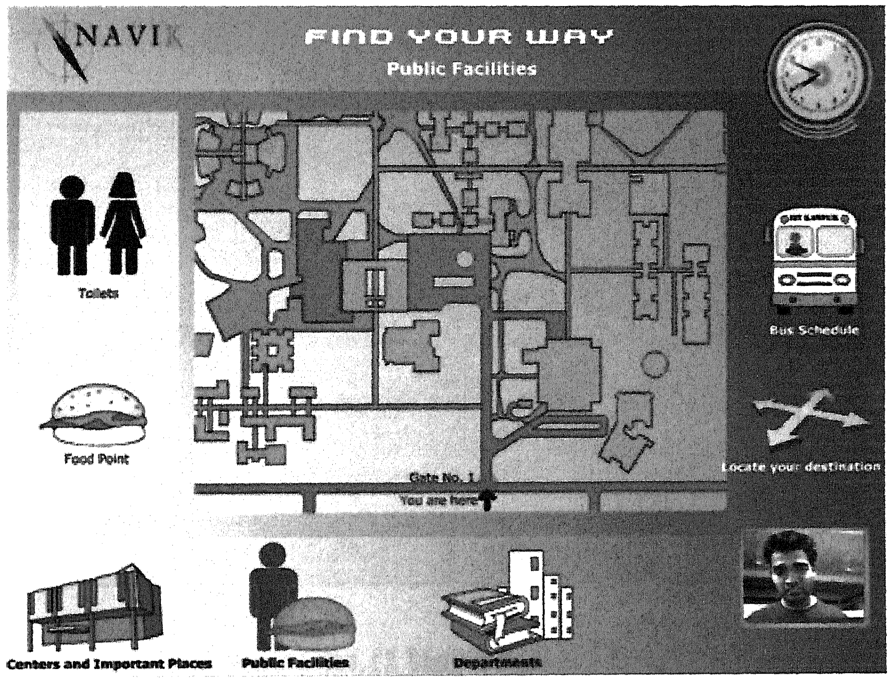


Figure 4.4.11 Interface for public amenities search

7) User data entry

This section is a hidden option behind the webcam video output. A small window at the bottom right corner displays a live video of the user using a webcam. The basic purpose of this element is to hold the users attention. This was observed during experimentation that a user develops interest by looking his/her own video on the screen. If user touches the window, it displays an user data entry form. This form is an optional thing and it is used to store the basic information about the demographic information of the users. This data can further be utilized to do analysis and modifications in the existing system.

Figure 4.4.12 Live video out from webcam

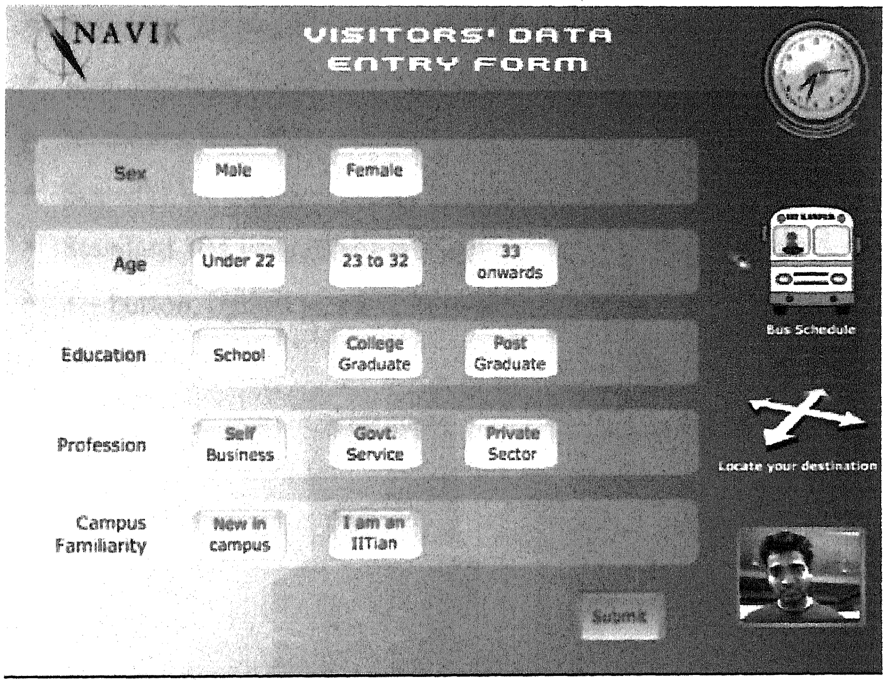


Figure 4.4.13 User data entry form

4.5 Tools and environment

This project was completed with the help of different hardware and software tools. Considering the latest advancements in the software tools as well as the increasing bandwidth, this application was designed. The system consists of a server as well as a client machine connected through 100 mbps Local Area network. This section describes the detailed specification of all the tools.

4.1.1 Hardware requirement

The hardware used for experimentations and final prototype consists of the following:

1. **Server Side**

   For running server applications as well as storing database, IBM ThinkCenter desktop (Model number M50 818712U) was used. The server has the following configurations:

   - Intel Pentium 4 Processor with Hyper-Threading Technology, 3.20 GHz, 512 KB Internal L2 cache memory size.
   - 512MB/4GB system memory (RAM)

- Serial ATA/Ultra ATA-100, 120 GB hard disk drive
- Intel Extreme Graphics 2, 2048x1536 256 colors Graphic Support
- Integrated Intel PRO/100 Ethernet
- SoundMAX Cadenza Audio Support
- Standard 104 keys IBM keyboard
- 3 – button, optical scroll IBM mouse

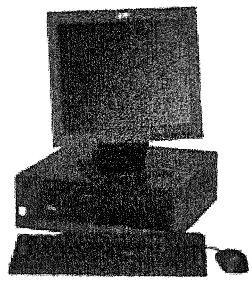


Figure 4.1.1 IBM ThinkCenter Server

2. Client Side

For running client side application, IBM ThinkCenter desktop (Model number A30 819866U) was used. The client system has the following parts:

- Intel Pentium 4 Processor 2.60 GHz, 512 KB Internal L2 cache memory.
- 512MB/2GB system memory (RAM)
- Serial ATA/Ultra ATA-100, 40 GB hard disk drive
- Intel Extreme Graphics 2, 2048x1536 256 colors Graphic Support
- Integrated Intel PRO/100 Ethernet

Figure 4.1.2 IBM ThinkCenter Clint

- SoundMAX Cadenza Audio Support
- Standard 104 keys IBM keyboard

- 3 – button, optical scroll IBM mouse
- *3M Microtouch®,* 14", 5-wire resistive Touch Screen

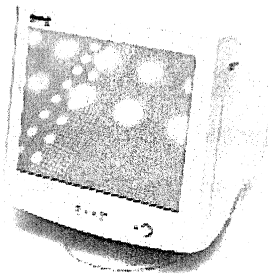


Figure 4.1.3 Microtouch Touch Screen (14")

- Webcam

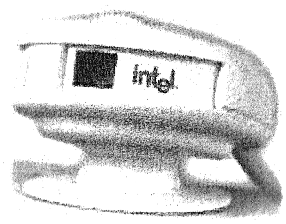


Figure 4.1.4 Intel webcam (Model Number CS330)

3. Network requirements

Although system can be made functional with any network requirement, but keeping a vision to implement multiple client kiosks, the system was designed to work on a 10/100 local area network. Where as, server and client needs 10/100 ethernet adapter. TCP/IP was the main communication protocol.

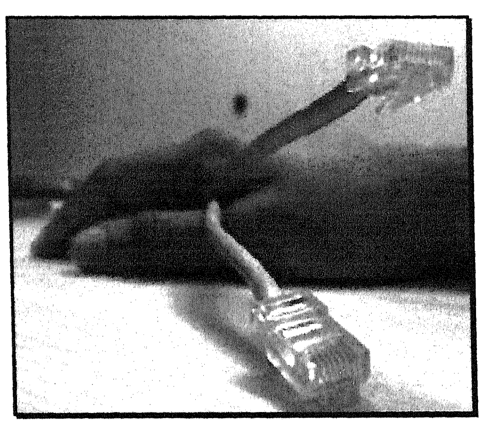


Figure 4.1.5 Local Area Network Connection Cable

4. Kiosk

The touch screen monitor needs to be placed at a sufficient height so that users can easily interact with the system while standing. The kiosk provides housing for touch screen monitor, CPU cabinet, Battery backup, speakers and webcam. Kiosk also provides a cooling unit such as fan for maintaining the temperature of electronic components.

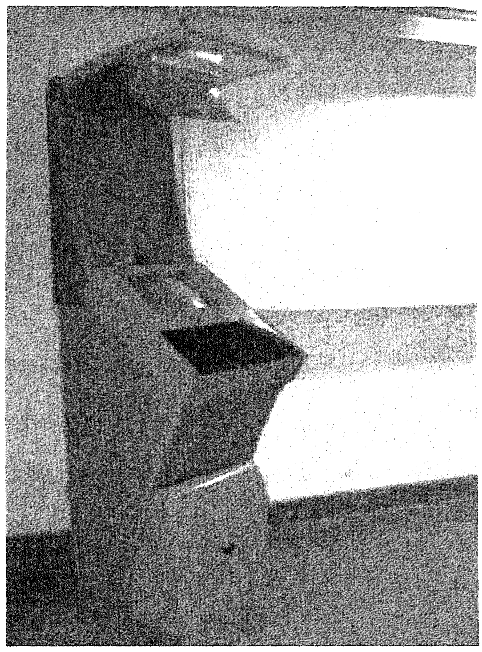


Figure 4.1.6 A Kiosk

4.1.2 Software requirement

The project was completed using different software applications, which are explained here:

1. Operating system

Window 2000 Professional has been used for server as well as client machines. This operating system has sufficient tools to design a medium level network application.

2. Internet Information Service (IIS) 5.0

The server system runs an inbuilt web server IIS 5.0 by Microsoft. Internet Information Services (IIS) 5.0 is a powerful Web server that provides a highly reliable, manageable, and scalable Web application infrastructure. IIS defines a basic functionality used to build Web applications. With IIS, Microsoft includes a set of programs for building and administering Web sites, a search engine, and support for writing browser-based applications that access databases. IIS can host HTML pages and run different scripts such as CGI PERL etc.

In this project IIS has been used to host HTML pages along with flash (swf) files. It also hosts CGI files which on execution in IIS environment, interact with the Microsoft access database for storing client side data.

3. Flash Communication Server MX 1.5

Flash communication server has been used separately as it has some additional features, which help in increasing interactivity and productivity of the application. Macromedia Flash Communication Server MX is a complete solution for creating and deploying streaming media and rich communication functionality in websites and Internet applications.

The product includes a professional set of application creation and debugging tools that are integrated into Macromedia Flash MX, and powerful server software that allows streaming of multi-way audio, video and data and create multi-user communications features that are accessible by the widely distributed Macromedia Flash Player.

Macromedia has released a new format for streaming video and audio files over the network. This format called ".flv" or *flash video* has been supported by flash communication server as well as flash player 6 +. Using these tools following applications has been implemented in the system:

1. Video capture using web cam
2. Video playback of recorded archives over the LAN
3. Live display of video in the interface

4. Flash Player 6.0

Flash player 6.0 is the minimum requirement of the system. The interface has been designed using flash MX 2004, and it can only be played using flash player plug-in which is supported by Microsoft internet explore 5.0. Flash player supports display of flash video and interaction with Microsoft access database using asp script files.

4.1.3 Development Tools

5. Flash MX 2004

Flash MX 2004 is a power tool for developing interactive application for web and multimedia. The main front-end design and complete interactive environment has been designed using tool. It was used for developing web-cam integration, network connectivity, audio integration and video displays. Action script 2.0 was used to add more interactivity to flash MX applications.

6. Dreamweaver MX

Dreamweaver MX 2004 is another tool for website design. This tool was used for embedding flash files (.swf files) into html pages and writing code for ASP files.

7. Adobe Photoshop 7.0

Photoshop is a very famous image-editing tool by Adobe. It was used to design background templates and image editing, throughout the project.

8. Final Cut Pro

This is video editing tool by Apple Corporation. This tool was used for editing videos used in the application. This tool cannot render video files into flash format, so Quick time player 6.0 has been used for converting mpeg files into flash video (.flv) format.

Chapter 5

Conclusions

In this final chapter we summarize by listing the contributions of this dissertation and recommending the directions for further research in this field.

5.1 Contributions of this dissertation

1. In this thesis a new rule has been devised to design menus and buttons for a touch screen based interface. This helps in solving the problem of obstructions created due to user's hand during interaction over a touch screen.

2. This thesis describes the techniques to catch users attention and to hold it for a long time. The implementation of live video output using webcam helps in holding the user's attention.

3. The implementation of *Fitts' Law* has been verified for touch screen based interaction. User access faster with large button size and with large spacing between them.

4. The results and inferences have been used to design a touch screen based information and navigation system for IIT Kanpur campus to locate departments and other important places within the campus.

5.2 Direction of further research

Public information system needs to be designed for easy access and heavy usage. The most important part is to design and improve the existing interfaces of the conventional systems. Touch screen based system are used in many places but the interfaces need to designed keeping the user's efficiency in mind. Some of the techniques can be applied in such system.

The final information system for IIT Kanpur has been designed considering users in the age range of 15 years and above. The research can be further extended considering children and disables. The information system can be made more responsive and intelligent enough to adapt itself according to the environment and climate change.

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